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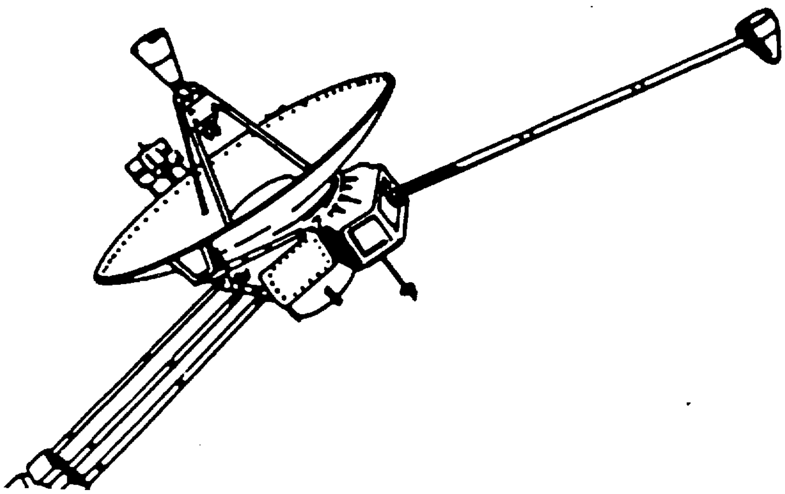

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(NASA-TM-108233) NASA DISCOVERY PROGRAM WORKSHOP Summary Report (NASA) 64 p

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NASA

DISCOVERY PROGRAM WORKSHOP

SUMMARY REPORT

NOVEMBER 16 - 20, 1992
SAN JUAN CAPISTRANO RESEARCH INSTITUTE
SAN JUAN CAPISTRANO, CALIFORNIA USA

SAN JUAN CAPISTRANO RESEARCH INSTITUTE

Center for Global Earth and Planetary Science Studies

M E M O

December 18, 1992

To: NASA Discovery Workshop Attendees

From: Doug Nash, Workshop Organizer

Subject: Summary report on results of Workshop Evaluation of Mission Concepts

As you know, the Discovery Program Mission Concept Workshop went off without a hitch November 15-20, 1992, in San Juan Capistrano. We had 246 registered attendees including 28 panel members, plus one special (surprise) guest, Mr. Dan Goldin, NASA Administrator, who spoke to the workshop on Wednesday noon.

On Friday, November 20, 1992, the workshop Evaluation Panel completed its evaluation of the 73 mission concepts submitted to the workshop. On Monday, November 23, 1992, individual evaluation reports, tailored for each concept, were mailed to the concept P.I.'s.

Attached here is the summary report, prepared by Evaluation Panel Chairman Geoffrey Briggs, that discusses the Evaluation Panel's process and their results. Each subpanel's evaluations are summarized in four matrices shown in Figures 1-4 in Briggs' report. Each matrix relates the subpanel's estimate of risk and science value of the concepts in that subgroup.

Also attached here is a list of all the concepts submitted, their P.I. and team members and institutions, the mission title, and a synopsis of each concept. Other information includes meeting agenda, subgroups summary, institutional summary, and list of all people who attended the workshop.

All responses and queries received at San Juan Institute from P.I.'s regarding their concepts will be responded to and eventually submitted to NASA Headquarters for inclusion in NASA's continuing evaluation of Discovery Mission concepts.

Finally, I want to thank all the concept submitters and their teams for their spectacular effort in coming up with so many great ideas for planetary exploration missions. NASA is indeed indebted to you for your imagination, professionalism, and hard work. It was a labor of love for you, and for us, to put on the workshop. I wish you all good luck for much success in your future activities.

Sincerely,

Doug

Doug Nash

DN:amg
attachment

cc: C. Pilcher
G. Briggs

31872 Camino Capistrano, San Juan Capistrano, California 92675 (714) 240-2010

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Report on the
Discovery Mission Concept Workshop

held at the
San Juan Capistrano Research Institute

16 to 20 November 1992

Geoffrey Briggs
Chairman, Evaluation Panel

December 18, 1992

The Discovery Mission Concept Workshop
held at San Juan Capistrano Research Institute 16–20 November 1992

Purpose

The overall purpose of the workshop was to review concepts for Discovery-class missions that would follow the first two missions (MESUR-Pathfinder and NEAR) of this new program. The concepts had been generated by scientists involved in NASA's Solar System Exploration Program to carry out scientifically important investigations within strict guidelines — $150 million cap on development cost and 3 year cap on development schedule. Like the Astrophysics Small Explorers (SMEX), such "faster, cheaper" missions could provide vitality to Solar System Exploration research by returning high quality data more frequently and regularly and by involving many more young researchers than normally participate directly in larger missions.

An Announcement of Opportunity (AO) to propose a Discovery mission to NASA is expected to be released in about two years time. One purpose of the workshop was to assist Code SL in deciding how to allocate its advanced programs resources. A second, complementary purpose was to provide the concept proposers with feedback to allow them to better prepare for the AO.

Organization

The 73 concepts submitted were divided into four sub-groups (these overlapped significantly): atmospheres (14 concepts); dust, fields and plasma (15 concepts); small bodies (23 concepts); and solid bodies (21 concepts). An evaluation of the merits of each concept was carried out by (four) sub-panels made up of both planetary scientists and space-project managers and engineers (see attachment). Each was assessed in terms of its potential scientific merit (given the proposed payload) and its likelihood of successful accomplishment within the given cost and schedule constraints.

The sub-panel members were sent the submitted concepts for their assigned area well ahead of the workshop. The scientific evaluation of the panel was assisted by the results of a mail review carried out ahead of the workshop, results which the panel incorporated into their final evaluation. The non-science aspects of the concepts were also examined ahead of the workshop by S.A.I.C. and these results were used by the sub-panels for additional guidance after they had carried out their evaluations.

During the workshop 73 presenters were each allotted 10 minutes in which to describe the concept and a further 10 minutes in which to answer questions. Because workshop organization allowed the sub-panel members to review the concepts ahead of time — and also because the presenters and sub-panel chairmen were well prepared and disciplined — this limited time allocation proved sufficient for the task. The workshop schedule was maintained throughout and no presenter encroached on another's allocation. Given the limited time available, plenary sessions of the evaluation panel were minimized and coordination was achieved mainly through meetings of the chairmen of the sub-panels before and during the workshop. Agreement was reached on the criteria and general approach to the evaluation of the concepts but no attempt was made to insist upon identical procedures. *Thus the reports and the evaluation categories of each sub-panel (see below) differ in detail and cannot be compared directly.*

A few concepts (#35 - A Planetary/Heliospheric Reconnaissance of Dynamics: Ionosphere, Thermosphere, and Exosphere, #37 - Venus CLOUD Mission, #95 - Polar Orbiters for Giant Planet Exploration, #60 - A Mercury Interior, Surface and Environment Mission, #78 - Comet Coma Sample Return, #46 - Flyby Sample Return Via Sample of Comet Coma Earth Return — SOCCER) substantially overlapped the interest of at least two sub-panels; their assignment to one panel or another was made in such a way as to balance the work load of the four panels. *Because the evaluations of the four panels have not been normalized, these few concepts — in particular — are subject to the caution not to compare rankings across sub-panels.*

Conflict of interest of panel members was avoided where necessary by such panel members abstaining from the panel consensus in reaching an overall evaluation of merit.

Format of the Evaluation

As indicated above, the sub-panels adopted similar, but not identical, approaches to concept evaluation. Each treated the science and the non-science aspects of the concepts as separable matters and evaluated them independently. In many instances concepts provided insufficient information for proper evaluation so that the sub-panels were required to resort to somewhat subjective judgments. In some cases it was not possible to render *any* judgment and ratings were assigned of *unknown*. After extended discussions, and numerous iterations, a *science merit rating* and a *risk rating* were assessed for each concept. Overall merit is, thus, measured by these two dimensions — the quality of the science and the lowness of the risk in the context of the Discovery constraints.

In order to provide both Code SL and individual proposers with an understanding of how the rating was reached, for each concept the sub-panels summarized their discussion into a written commentary divided into *strengths, weaknesses, uncertainties* and *comments*. It is hoped that this summary will serve as substantive and constructive feedback to individual proposers looking forward to the Discovery AO.

Thus, each concept evaluation consisted of 1. a rating for science merit and a rating for risk, and 2. a written assessment of strengths, weaknesses, uncertainties and comments. The ratings for each sub-panel were plotted as a two dimensional matrix (figures 1 to 4) with the highest ranked concepts in the top left matrix elements. *The four matrices (one for each subgroup of concepts) have not been normalized and each must, at this time, stand alone.* Each workshop participant has been mailed a copy of the four matrices together with the commentary on his or her individual concept.

General Observations

The overall quality and innovativeness of the concepts was remarkably high, although not always complete (especially in management related areas). The concepts were also extremely diverse and included observatories, space-station payloads, flyby spacecraft, orbiters, atmospheric probes, aeroplanes, rough landers and sample return spacecraft. Targets ranged from Mercury to Pluto and Chiron (and beyond — there was one concept to discover terrestrial planets about other solar-type stars).

Spacecraft included spinners and three-axis stabilized vehicles, many of which have heritage or anticipated heritage from the new generation of small, capable vehicles being developed by industry. The issue of credible heritage, of critical importance if the quoted costs were to be at all credible, arose in many cases. The credibility of a number of the concepts hinges on the outcome of decisions that NASA will be making over the next several years — the ability to inherit spacecraft designs from MESUR, NEAR, and from a Pluto mission in planning. Others depend on non-US spacecraft such as SOCCER, Venera, and Mars/Phobos.

Power ranged from solar panels to batteries and RTGs. The need to use the latter, highly expensive devices to operate in the outermost solar system raises the question (below) of whether the Discovery program missions must be limited to the inner solar system.

International partnerships were proposed by a number of participants evidently both as a cost sharing mechanism and because of unique capabilities that others have. Inevitably, questions arise about the compatibility between Discovery class missions — which need maximum PI/Project Manager control for success — and the intrinsic complexity and uncertainty of international partnerships.

Few of the concepts showed evidence of serious consideration of management issues, issues which the evaluation panel believes will be as important to the success of the Discovery program as scientific and technical considerations. Among other considerations, management structures often showed more layers than are compatible with a swift small project i.e. business-as-usual. In some cases where the proposed project management was more streamlined the respective responsibilities of the Principal Investigator and the (usually unnamed) Project Manager were not clearly described.

The management guidelines for the program recommended in July 1991 by the Discovery Program Cost and Management Team (J.S. Martin, chair) do not appear to have received wide circulation among the community. These guidelines remain operative and will need to be taken to heart by both NASA and potential proposers to future AOs. Generally speaking, the sub-panels did *not* down-grade concepts based on the quality of the management scheme proposed *nor* on the apparent degree of experience (or lack thereof) of the proposer. Thus the risk evaluations for the concepts may better be regarded as *potential* risk *assuming that an appropriate management scheme is adopted* (along the lines recommended by J.S. Martin et al).

When responses are received to the future AO, management considerations will be of paramount importance if the Discovery program is to succeed. Code SL clearly needs to work this issue further and provide additional guidelines to the community.

Some concepts required less in the way of launch vehicle capability than others. Some concepts (notably Earth orbital missions) aimed at total costs significantly lower than the $150M upper limit placed on Discovery missions. Because there were generally too many uncertainties in establishing the real total cost of the mission concepts, the evaluation panel could not assess *science value* ("bang for the buck") and may, therefore, have inadvertently penalized some proposals. The panel recognizes that value *is* an important factor that NASA will have to grapple with if it is to carry out a Discovery program in the spirit in which it was conceived.

Results of the Workshop

The four matrices shown in Figures 1 to 4 have a sufficient population of high quality concepts that there is no doubt that a powerful Discovery program can be planned on the basis of concepts already identified e.g. a two decade program with one launch per year could be based on the high quality concepts presented at this workshop alone. Following the admonition of Administrator Goldin in his remarks to the workshop that "we should not aim too low" the workshop results suggest that a Discovery program involving multiple annual launches would, indeed, be feasible. Certainly, more high quality concepts were identified than Code SL Advanced Programs has resources (about $1M based on Advanced Studies Chief Carl Pilcher's estimation) to support, so Code SL will certainly have a difficult task deciding how to allocate these resources.

Atmospheres Missions Sub-Panel (Fig. 1)

Five concepts fall into the matrix elements for exceptional or high science merit *and* low or medium risk, namely #04 - Venus Multiprobe Mission, #12 - Venus Orbiter/Deep Atmosphere Temperature Sounder, #17 - Venus Composition Probe, #74 - Radio Science & Astronomy Mission, Giant Outer Planets Orbiter, and #79 - A Mars Upper Atmosphere Dynamics, Energetics and Evolution.

Concept #74 calls for the use of an RTG and the Atmospheres Sub-Panel (unlike the others) chose not to include the cost of the RTG in their evaluation of the risk of carrying out the mission within the Discovery guidelines. The sub-panel noted in their report that "if it [the RTG cost] had been [included], the cost [of the mission] most assuredly would exceed the $150 million ceiling."

Concept #92 was unrated since it is not a mission concept but a strategy for international cooperation.

Dust, Fields, Plasma Missions Sub-Panel (Fig. 2)

Five concepts fall into (or on the edge of) the matrix elements for exceptional or high science merit *and* low or medium risk, namely #01 - The Cosmic Dust Collection Facility, #13 - Earth Orbital UV Jovian Observer, #37 - Venus CLOUD Mission, #78 - Comet Coma Sample Return Mission, and #93 - Satellite for Imaging Planetary Alkaline Comas.

The sub-panel noted in their report that #37 - Venus CLOUD Mission and #78 - Comet Coma Sample Return Mission might have been considered by other sub-panels. The sub-panel report also recommended that "you do not limit your consideration for assistance to only those concepts rated the highest since many of the concepts presented would pursue interesting science investigations if programmatic improvements could be made."

Small Bodies Missions Sub-Panel (Fig. 3)

Seven concepts fell into the matrix elements for very high or high science merit *and* low or medium risk, namely #6 - Small Missions to Asteroids and Comets, #18 - Comet Nucleus Tour, #23 - Cometary Coma Chemical Composition, #40 - SOCCER Pathfinder, #47 - Main Belt Asteroid Exploration/Rendezvous #79 - Comet Nucleus Penetrator, #77 - Near-Earth Asteroid Sample Return.

In their cover letter the sub-panel commented, "It should be noted that the various concepts reflected widely varying degrees of completeness especially in the technical, schedule, and cost elements. Therefore, the evaluation adjectives must be viewed as judgments, based on incomplete and/or insufficient data."

The sub-panel noted also that, "The science goals of planetary exploration are relatively invariant with respect to the management and engineering challenges envisioned by the Discovery program. Hence, it is not surprising that most of the concepts received reflect attempts to do the same range of missions as previously suggested, and to first order, one can relate their goals quite directly with those outlined by previous recommendation reports, e.g. the COMPLEX report on primitive body missions, and the SSEC reports."

One concept allocated somewhat arbitrarily to the sub-panel was in a separate category from all the others: #61 - Frequency of Earth-Sized Planets. This concept is an approach to discovering other planets, the subject of the TOPS program ("Towards Other Planetary Systems"), and the only TOPS concept submitted to the workshop. The sub-panel was impressed with the concept of discovering terrestrial-type planets about other stars using a CCD photometer to "stare" at thousands of solar-type stars for three or more years. The sub-panel noted that this proposal would have received the highest ranking of all if the sub-panel in question had believed the CCD technology could achieve the required photometric stability.

Solid Bodies Missions Sub-Panel (Fig. 4)

Five concepts fell into the matrix elements for very high to high science merit *and* low to medium risk: #15 - Mercury Polar Flyby, #44 - Lunar Interior Explorer Mission, #55 - Discovery Venera Surface Atmosphere, Geochemistry Experiments, #65 - A Lunar Polar Orbiter Mission, and #83 - The Mars Polar Pathfinder.

One concept (# 92 - Exploration of Mars in the 90s) was considered to be too general in nature to evaluate in the same terms as the other concepts and, therefore, was not given an evaluation. However, see ***Issues* — *The first Discovery Mission*** below.

The evaluation panel was impressed with the potential of two concepts having great science value but insurmountable technology problems today — specifically high temperature electronics for long-lived Venus surface probes. Such probes also, apparently, need RTG power and are, thus, doubly handicapped. Nevertheless, the evaluation panel believes Code SL Advanced Studies should be working with the technology side of NASA to open up the opportunity to explore high temperature environments.

The sub-panel noted that "Taken together, the breadth and depth of the concepts was very impressive, and almost overwhelming."

General Discussion

High quality concepts (excellent science/potential low to medium risk) include almost the full range of diversity mentioned at the outset — from Mercury to the comets and main belt asteroids, observatories, a space station payload, atmospheric probes, orbiters, a lander, and sample return. The outer solar system remains problematical, however, because of the expense of procuring RTGs and carrying out the analyses necessary to acquire launch approval of nuclear material. This matter is further discussed under **Issues** below.

Many concepts judged to be of lesser science value and/or of high potential risk were also considered to be both highly innovative and worth support. In some cases the "potential heritage" was considered insecure at this time; in some cases the changes needed to available spacecraft were considered to be too numerous to be achieved within the tight Discovery cost envelope; in some cases the instrumentation proposed was considered to not be sufficiently developed; in some cases the payload was considered to be too ambitious; and for all the outer solar system missions the power problem loomed large (the proposed use of battery power for a Pluto flyby was a notable innovation to surmount this problem). The evaluation panel was, in fact, presented with an extreme variety of "apples and oranges" to categorize and was able to carry out its assignment only by using a very coarse grid for the merit matrix. The lesser science/high risk bins of the four sub-panel matrices therefore *contain concepts with a very wide range of intrinsic merit,* some of which may well, in modified form, be serious contenders for the Discovery program or for other Code SL programs later.

Some potentially exciting concepts described technologies that could contribute significantly to the exploration of the solar system — a Mars aeroplane, a lunar legged rover, a solar electric spacecraft — but were lacking comparably exciting scientific justifications. The concepts, inevitably, suffered in the evaluations of the sub-panels.

Issues

Radioisotope Thermoelectric Generators

Presenters with outer planet concepts generally proposed the use of RTGs for their missions (one battery powered and one solar-array powered concept were also described) and assigned a cost of between $15M and $50M for the needed procurement and launch approval. In the context of the Discovery program cost and schedule guidelines, the evaluation panel was obliged to assign a high risk rating to all these concepts.

Unless circumstances change over the next few years it seems unlikely that such missions can be serious candidates for inclusion in the Discovery program. Code SL must consider whether or not this is an acceptable situation. Given that, over the years, the price of RTGs negotiated between NASA and DOE has always been based on complex economics and politics (since the production of Plutonium 238 for RTGs has always been a by-product of facilities justified for nuclear weapons material) it is conceivable that NASA might deliberately subsidize RTGs for the Discovery program. The issue is, inevitably, a complicated one especially since the nature of the Discovery program is less compatible with the idea of subsidy (overt or buried) than larger business-as-usual programs.

Launch Vehicles for Outer Solar System Missions

Another problem facing proposers of concepts to explore the outermost solar system is the long trip times if launch vehicles no larger than the Delta are available. One proposer (90 - Chiron Discovery Flyby) took note of the discussions that have apparently taken place with the Russians about the possible use of Proton launchers to launch two separate Pluto Flyby spacecraft (a potential JPL-managed mission not in the Discovery program). Given present prices, Protons might well be no more expensive than Deltas. The many issues surrounding the acquisition of such vehicles are issues with which the evaluation panel is not qualified to deal. Lacking any insight into the practicality of acquiring Protons, the need for such vehicles was treated by the panel as an element of high risk. The practicality of acquiring spare JPL-built spacecraft for missions like a Chiron flyby was also treated as a high risk element.

Launch Vehicles and Operations Costs

Some concepts were compatible with launch vehicles much smaller and less expensive than the Delta that has been the specific *not-to-exceed* vehicle for Discovery missions. Some concepts required minimal operations support, some required 10 years of operations. Evidently some concepts may well represent better *value* ("bang for the buck") than others. Code SL must find some way to include value into the criteria that are used to decide how to allocate Advanced Study resources (and to evaluate responses to the future Discovery AO) in order to motivate the community to bring forward such concepts in the future. (It is noted in passing that the tendency towards maximizing the absolute science value of missions without sufficient consideration of cost has contributed to the need for the Discovery program to be brought forward.) Perhaps the simplest way to do so would be (as Administrator Goldin suggested to the workshop) to include added resources for the launch vehicles and mission operations directly in the Discovery program budget.

International Concepts

The evaluation panel was somewhat hard-pressed to deal with the international concepts on the same basis as other proposals. All things being equal, by sharing the cost of the mission with a partner a proposal can certainly expect to produce more value. However, the Discovery program concept is based on the idea of giving an investigator the resources and authority to get a well-defined task accomplished in a limited time. International partnerships inevitably diffuse authority and introduce elements quite outside the control of a selected investigator. Thus, the evaluation team assigned more risk to partnership missions than to simple concepts.

It must be acknowledged that international Astrophysics Explorer missions have been carried out in the past and this experience base should be assessed before reaching any fixed conclusion concerning the advantages and disadvantages of international collaborations.

Required ATD (Advanced Technology Development) Resources

Discovery program projects are required to be completed in a tight three year phase C/D schedule. Even more than "standard" missions the spacecraft subsystems and payload must be fully ready before entering the development and build phase (C/D). More than a decade ago, the so-called Hearth Committee (Don Hearth, chairman), in a widely acknowledged report, concluded that the lack of sufficient spending during definition (phase A/B) was the principal reason for cost growth during a project. Specifically, the Committee recommended that 6 to 8% of a projects anticipated cost be spent during definition to ensure that all major problems be identified and solved or worked around prior to phase C/D.

If the Discovery program is to succeed adequate resources *must* be available for definition. Typically, a selected project will need to spend $6 to $10M over a two year period in order to be ready. NASA should not begin another brave new program unless and until it has the resources to provide each project with adequate definition.

The first Discovery mission

MESUR Pathfinder has been selected by Code SL to be the first mission of the Discovery program, followed by the Near Earth Asteroid Rendezvous mission (NEAR). Neither were the subject of evaluation at the workshop. The NEAR mission had, however, received substantial review by the Discovery Science Working Group more than a year ago and is demonstrably based on a concept that fits the Discovery program guidelines. Concern was expressed at the workshop by one of the proposers (#92 - Exploration of Mars in the 90s) that the MESUR Pathfinder is a highly anomalous mission with which to begin the program because, as presently conceived, the project is only a technology demonstration project. The proposer suggested alternative ways, involving extensive use of already developed Russian Mars lander vehicles, to allow a science driven MESUR to proceed within the guidelines of the Discovery program.

The evaluation panel is in no position to assess the merits of MESUR Pathfinder but, given that the proposer's concern is evidently widespread, acknowledgment of this concern is judged to be necessary.

THE WORKSHOP EVALUATION PANEL

Workshop Organizer: Doug Nash - SJI

Panel Chairman: Geoffrey Briggs - NASA ARC

Atmospheres Missions Sub-Panel

Frank Carr - JPL, **Chairman**
Stillman Chase - Consultant
C. Barney Farmer - SJI, **Lead Scientist**
Ken Fox - U. Tennessee
Don Hunten - U. Arizona
Don Pinkler - NASA HQ (in absentia, written input only)
Ken Sizemore - NASA GSFC

Dust, Fields, and Plasma Missions Sub-Panel

Jim Moore - NASA GSFC, **Chairman**
Alex Dessler - Rice U, **Lead Scientist**
Robert Johnson - U. Virginia
Rex Ridenoure - JPL
Steve Paddack - NASA GSFC
Herb Zook - NASA JSC

Small Bodies Missions Sub-Panel

Jim Martin - Consultant, **Chairman**
Al Harris - JPL
Bill Quaide - SAIC
Jack Lissauer - SUNY, Stony Brook, **Lead Scientist**
Al McEwen - USGS
Hank Norris - Consultant
John Pyle - NASA GSFC

Solid Bodies Missions Sub-Panel

Gentry Lee - Consultant, **Chairman**
Doug Blanchard - NASA JSC, **Lead Scientist**
Tom Economou - U. Chicago
Gene Giberson - Consultant
Larry Soderblom - USGS

Organizing Committee

Carl Pilcher - NASA HQ
Henry Brinton - NASA HQ
Jurgen Rahe - NASA HQ
Doug Nash - SJI
Geoffrey Briggs -NASA ARC
Richard Vorder Bruegge - SAIC
Pat Dasch - SAIC

COMPOSITE SUMMARY of DISCOVERY CONCEPTS

SCIENCE & RISK EVALUATIONS

SUBGROUP FINAL RESULTS:

_X_ *ATMOSPHERES* __ *SMALL BODIES*

__ *DUST, FIELDS, PLASMAS* __ *SOLID BODIES*

RISK OF ACHIEVING DISCOVERY PRINCIPLES >>>>>>

RISK: / SCIENCE MERIT:	LOW	MEDIUM	HIGH	UNKNOWN
EXCEPTIONAL	04 (17)	17, 79 (04)	(79)	
HIGH	(12, 38) (7	12, 74 4) (4 (1	16, 38, 49 9) 6)	
MEDIUM			03, 98 (03, 98)	
LOW (L) OR UNKNOWN (?)		51 (?) (8	80 (L), 99 (L) 0) (51, 99)	

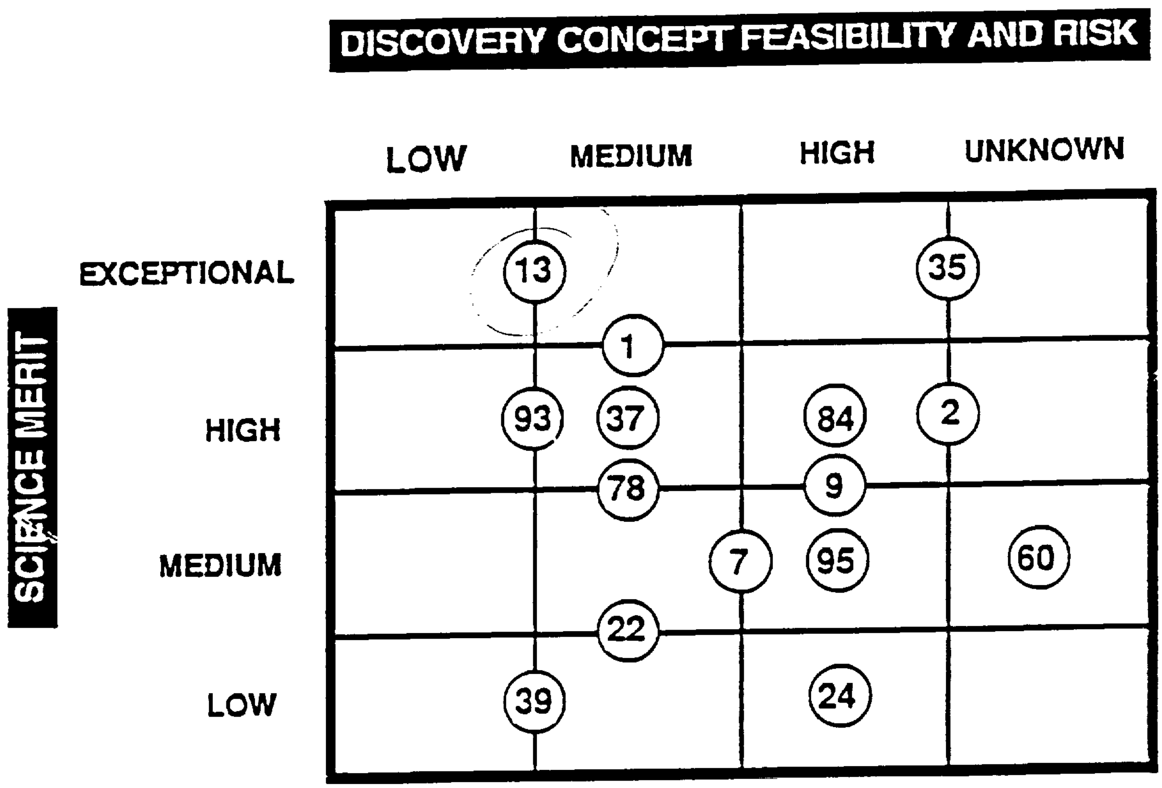
NOTES: SAIC scores for technical & programmatic feasibility in (parens).

1. See "EVALUATION PANEL HANDBOOK" for definition of Concept Numbers, and Cover Letter for special considerations.
2. NO RANKING within boxes

FAC: November 20, 1992

Figure 1

SUMMARY EVALUATION
Dust, Fields and Plasma Missions



Note: The results of the four Discovery Workshop subgroups have not been normalized, so this matrix should not be compared directly with the other three; ranking categories with similar names may not be comparable.

Figure 2

Discovery Workshop Nov. 16–20, 1992

Concept Evaluation
"Small Bodies" Sub Panel Comments
Summary

Discovery Programmatics

Science Value		Low Risk	Med. Risk	High Risk	Unknown
	Very High	47, 76		100	
	High	18, 6	23, 40, 77	32, 90	
	Medium	26	5, 29, 88	11, 14, 46, 54, 61, 75, 85	20, 73

Figure 3

ASSESSMENT MATRIX—SOLID BODIES SUBPANEL

SCIENCE VALUE	CONSISTENCY WITH DISCOVERY				
	Low Risk	Medium Risk	Medium to High Risk	High Risk	High to Very High Risk
Very High		83			81, 42
High to Very High		15	52	34, 53, 66	
High	44, 65	55			
Medium to High	28	43, 58		96	
Medium	97	86, 94			
Unknown		87, 64			

Not ranked Concept 72

Figure 4

AGENDA
(Actual)

NASA DISCOVERY PROGRAM MISSION CONCEPT WORKSHOP

Nov. 15 - 20, 1992

San Juan Capistrano Research Institute
31872 Camino Capistrano
San Juan Capistrano, CA. 92675
Phone (714) 240-2010
Fax (714) 240-0482

Workshop Sponsor: NASA Solar System Exploration Division, Advanced Studies Branch

Local Organization: San Juan Institute (SJI)

Organizing Committee: C. Pilcher (NASA HQ)
D. Nash (SJI)
G. Briggs (NASA/ARC)
J. Rahe (NASA HQ)
R. Vorder Bruegge (SAIC)
P. Dasch (SAIC)

Sunday, November 15, 1992

P.M. 5:00 - 8:00 Registration and Social Mixer, With Food

Monday, November 16, 1992 [Open Sessions, 22 Concept Presentations]

A.M. 7:30 Registration Continues

8:00 **Welcome and Logistics**
C. Pilcher (Solar System Exploration Div.)
D. Nash (Local Organizer)

8:10 **Format and Objectives of Workshop**
G. Briggs (Evaluation Panel Chairman)

SESSION 1* - ATMOSPHERES MISSIONS [14 Concepts]

8:20 R. Goody (Harvard) (C#4)
Venus Multiprobe Mission (VMPM)

8:40 C. Counselman (MIT) (C#98)
Venus' Rotation and Atmospheric Dynamics Using Grounded and Floating Radio Beacons

9:00 J. Arnold (UC San Diego) (C#99)
University Cooperative Venus Mission

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

	9:20	S. Gulkis (JPL) (C#12) **Venus Orbiter--Deep Atmosphere Temperature Sounder**
	9:40	F. Taylor (Oxford) (C#16) **Venus Atmospheric Dynamics Imaging Radiometer (VADIR)**
	10:00	BREAK
	10:20	L. Esposito (U. Colorado) (C#17) **Venus Composition Probe**
	10:40	K. Baines (JPL) (C#38) **Venus 4-D Discovery Mission**
	11:00	S. Limaye (U. Wisconsin) (C#49) **Mars Operational Environmental Satellite (MOES)**
	11:20	J. Langford (Aurora Flight Sciences) (C#51) **Mars Atmospheric Aircraft Platforms**
	11:40	LUNCH
P.M.	1:00	J. Anderson (U. Wisconsin) (C#3) **Martian Climate Variability, A Microsat Approach**
	1:20	T. Killeen (U. Michigan) (C#79) **A Mars Upper Atmosphere Dynamics, Energetics and Evolution**
	1:40	D. Lyons (JPL) (C#80) **The Little Dipper: Mars Aeronomy, Gravity, and Radio Science**
	2:00	D. Sweetham (JPL) (C#74) **Radio Science & Astronomy Mission (RSAM), Giant Outer Planets Orbiter**
		<u>SESSION 2*</u> - DUST, FIELDS, PLASMA MISSIONS [15 Concepts]
	2:20	F. Horz (JSC) (C#1) **The Cosmic Dust Collection Facility**
	2:40	W.H. Smith (Washington Univ.) (C#24) **A Space Experiment**

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

3:00 J. Mulholland (POD Associates, Inc.) (C#22)
Spatio-Temporal Monitoring of Space Debris

3:20 BREAK

3:40 T. Wdowiak (U. Alabama at Birmingham) (C#7)
Ultraviolet Imaging Spectroscopy of Meteors

4:00 D. Burnett (Caltech) (C#9)
Solar Wind Sample Return Mission

4:20 D.E. Shemansky (USC) (C#84)
A Proposal for Atmospheric Exploration of the Moon

4:40 H. Waite, Jr. (Southwest Research Inst.) (C#35)
A Planetary/Heliospheric Reconnaissance of Dynamics: Ionosphere, Thermosphere, and Exosphere (APHRODITE)

5:00 C. Russell (UCLA) (C#37)
Venus CLOUD Mission

5:20 ADJOURN

Tuesday, November 17, 1992 [Open Sessions, 26 Concept Presentations]

SESSION 2* (Cont.) - DUST, FIELDS, PLASMA MISSIONS

A.M. 8:00 G. Orton (JPL) (C#2)
Jupiter Polar Orbiter

8:20 J. Warwick (Radiophysics, Inc.) (C#95)
Polar Orbiters for Giant Planet Exploration

8:40 M. Hickman (NASA-Lewis) (C#39)
Magnetospheric Mapping and Current Collection in the region from LEO to GEO

9:00 R. Reedy (Los Alamos National Lab.) (C#60)
A Mercury Interior, Surface and Environment Mission Concept

9:20 P. Feldman (Johns Hopkins Univ.) (C#13)
Earth Orbital UV Jovian Observer

9:40 BREAK

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

10:00 M. Mendillo (Boston Univ.) (C#93)
Satellite for Imaging Planetary Alkaline Comas (SIPAC)

10:20 W.M. Alexander (Baylor Univ.) (C#78)
Comet Coma Sample Return (CCSR)

<u>SESSION 3*</u> - SMALL BODIES MISSIONS [23 Concepts]

10:40 M. Neugebauer (JPL) (C#5)
A Comet Impact Mission

11:00 B. Clark (Martin Marietta) (C#14)
Comet Coma Rendezvous Sample Return (CCR-SR)

11:20 J. Veverka (Cornell) (C#18)
Comet Nucleus Tour - CONTOUR

11:40 G. Carle (NASA-ARC) (C#23)
Cometary Coma Chemical Composition -C4- Mission

12:00 LUNCH

P.M. 1:00 J. Brandt (U. Colorado) (C#26)
The Small Comet and Interplanetary Hydrogen (SCIH) Discovery Mission and Ultraviolet Solar System Observer (UVSSO)

1:20 J. Burch (Southwest Research Inst.) (C#29)
Comet Activity Probe (CAP)

1:40 P. Weissman (JPL) (C#40)
SOCCER Pathfinder

2:00 A. Albee (Caltech) (C#46)
Flyby Sample Return Via Sample of Comet Coma Earth Return - SOCCER

2:20 W.H. Smith (Washington Univ.) (C#73)
The Comet Nucleus Observer

2:40 W. Boynton (U. Arizona) (C#76)
Comet Nucleus Penetrator

3:00 M. Belton (NOAO, Kitt Peak) (C#6)
SMACS: Small Missions to Asteroid and Comets

3:20 BREAK

3:40 R. Housley (Rockwell Internat. Sci. Ctr.) (C#11)
Asteroid Sample Return Mission

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

4:00 D. Britt (U. Arizona) (C#32)
Rendezvous with Earth Approaching Asteroids (REAAct)

4:20 E. Shoemaker (USGS-Flagstaff) (C#77)
Near-Earth Asteroid Sample Return (NEARS)

4:40 J. Veverka (Cornell) (C#47)
Main belt Asteroid Exploration/Rendezvous (MASTER)

5:00 J. Kumer (Lockheed Palo Alto Res. Lab.) (C#88)
Solar System Exploration Cryogenic-Telescope (SSECT)

5:20 D. Blake (NASA-ARC) (C#20)
CHEMIN: Chemistry and Mineralogy Using Combine X-Ray Fluorescence and X-Ray Diffraction

5:40 B. Murray (Caltech) (C#54)
Pluto/Charon Flyby Mission

6:00 A. Stern (Southwest Res. Inst.) (C#90)
Chiron Discovery Flyby

6:20 ADJOURN

Wednesday, November 18, 1992 [Open Sessions, 25 Concept Presentations]

SESSION 3* - (Cont.) SMALL BODIES MISSIONS

A.M. 8:00 W. Smythe (JPL) (C#85)
Io Mapper

8:20 B. Edwards (Los Alamos Nat. Lab.) (C#75)
Prospector Mission

8:40 T. Duxbury (JPL) (C#100)
Joint Russian/U.S. Phobos Sample Return Mission

9:00 W. Borucki (NASA-ARC) (C#61)
FRESIP: Frequency of Earth-Sized Planets

SESSION 4* - SOLID BODIES

9:20 P. Spudis (LPI) (C#15)
Mercury Polar Flyby

9:40 F. Vilas (NASA-JSC) (C#28)
Inner Planet Spectrographic Imaging Telescope (IPSIT)

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

	10:00	BREAK
	10:20	R. Nelson (JPL) (C#34) **Hermes Global Orbiter: A Mission to Mercury**
	10:40	D. Muhleman (Caltech) (C#52) **MIRROR: Mercury Imaging and Radar Ranging Orbital Reconnaissance**
	11:00	A. Metzger (JPL) (C#53) **Mercury Mapping Orbiter Mission**
	11:20	B. Bills (NASA-GSFC) (C#66) **Mallcu: Mercury Polar Orbiter Mission**
	11:40	S. Peale (UC Santa Barbara) (C#96) **Mercury Geophysics Mission**
	12:00	D. Goldin (NASA Administrator) **Comments and Discussion about Discovery, NASA, and the Nation**
P.M.	1:30	LUNCH
	2:00	J. Head (Brown Univ.) (C#55) **Discovery Venera Surface Atmosphere Geochemistry Experiments (SAGE)**
	2:20	M. Malin (Malin Space Sci. Systems) (C#42) **Venus Geophysical Network Pathfinder**
	2:40	E. Stofan (JPL) (C#81) **Venus Interior Structure Mission (VISM)**
	3:00	B. Bills (NASA-GSFC) (C#65) **Koati: A Lunar Polar Orbiter Mission**
	3:20	W.H. Smith (Washington Univ.) (C#72) **Lunar Ultra-violet Infrared Spectrometer**
	3:40	J. Plescia (JPL) (C#43) **Lunar Interior Explorer Mission**
	4:00	BREAK
	4:20	J. Plescia (JPL) (C#44) **Lunar Geophysical Explorer Mission**
	4:40	P. Bender (U. Colorado) (C#58) **Lunar Interior Structure Mission**

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

	4:50	L. Mason (NASA-Lewis) (C#64) **Combined Lander and Instrumented Rover (CLIR) A Robotic Lunar Rover Mission Proposal**
	5:05	W. Whittaker (Carnegie Mellon Univ.) (C#87) **Lunar Lava Tube Explorer**
	5:25	D. Scott (Scott Sci. and Tech., Inc.) (C#94) **ULYSSES: A Return to The Hadley Apennine, New Steps in Solar System Exploration**
	5:40	E. Hansen (U. Colorado) (C#97) **The Lunar Educator**
	6:00	D. Paige (UCLA) (C#83) **The Mars Polar Pathfinder**
	6:15	W. Fowler (U.Tex, Austin) (C#86) **Mars Gravity Measurement/Surface Penetrator Assembly Mission**
	6:30	J. Blamont (U. Paris & JPL) (C#92) **Exploration of Mars in the 90's**
	6:45	ADJOURN

Thursday, November 19, 1992 [Closed Panel Sessions]

A.M.	8:30	Evaluation Panel Meetings
	12:00	LUNCH
P.M.	1:30	Subpanel Meetings (continued)
	5:00	DINNER
	7:00	Subpanel Meetings and Writing Sessions
	10:00	ADJOURN

Friday, November 20, 1992 [Closed Panel Sessions]

A.M.	8:30	Subpanel Meetings and Writing Sessions
	12:00	LUNCH
P.M.	1:00	Subpanel Presentations to SSED Advanced Studies Chief
	5:00	Subpanel Final Concept Evaluation Reports Preparation
	7:00	ADJOURN. Conclusion of Workshop

* All Presentations Limited to 10 Min. Oral, 10 Min. Discussion, & 10 Viewgraphs

DISCOVERY WORKSHOP ATTENDEES

Last Name	First Name	Affiliation	Phone
Abshire	Jim	NASA/GSFC	301-286-2611
Adams	Jerry	Hughes Space & Comm. Co.	310-364-7008
Albee	Arden	Caltech	818-356-6140
Alexander	W.M.	Baylor University	817-755-3405
Allen	Lex	Tracor Aerospace	
Anderson	Drucella	NASA Public Affairs	202-453-1010
Anderson	John R.	U. Wisconsin	608-262-0783
Applewhite	Roger	Altadena Instruments	818-405-1812
Arnold	James	UC San Diego	619-534-2908
Baines	Kevin H.	JPL	818-354-0481
Basilevsky	Alexander	Brown University	401-863-1437
Baumgardner	Jeff	Boston University	617-353-5258
Beckman	John	JPL	818-354-2476
Bell	Jeffrey F.	U. Hawaii	808-956-3136
Belton	Michael J.S.	NOAO	602-327-5511
Bender	Peter L.	JILA- U. Colorado	303-492-6793
Berge	Larry	McDonnell Douglas- Delta Launch	714-896-1173
Bills	Bruce	NASA/GSFC	301-286-8555
Blake	David F.	NASA/ARC	415-604-4816
Blake	Jack	Rocketdyne Div. Rockwell Intern.	818-718-4865
Blamont	Jacques	CNES	33-1-4508-7611
Blanchard	Doug	NASA/JSC	713-483-5151
Borucki	William J.	NASA/ARC	415-604-6492
Boynton	William V.	U. Arizona	602-621-6941
Brace	Larry	U. Michigan/GSFC	301-286-8575
Brandt	J.	LASP- U. Colorado	303-492-3215
Briggs	Geoffrey	NASA/ARC	415-604-0218
Britt	Daniel	U. Arizona	602-621-8805
Broadfoot	Lyle	U. Arizona	602-621-4303
Brunk	William	USRA	202-479-2609
Burch	J.L.	S.W.R.I.	512-522-2526
Burke	Jim	Planetary Society	818-793-5100
Burnett	Don	Caltech	818-356-6117
Caldwell	John	SAL/ISTS & York University	416-665-5449
Carle	Glenn C.	NASA/ARC	415-604-5765
Carr	Frank A.	JPL	301-286-8263
Carroll	Mike	Astronomy Magazine	619-292-5460
Cauffman	D.P.	LPARL	415-424-3390
Chapman	Clark R.	PSI/SAIC	602-881-0332
Chase	Stillman	Consultant	805-967-2883
Cheng	Andrew F.	APL, Johns Hopkins Univ.	301-953-5415
Clark	Benton	Martin Marietta	303-971-9007
Coombs	Casssandra	POD Associates, Inc.	505-243-2287
Coughlin	Thomas B.	APL, Johns Hopkins Univ.	301-953-5012
Counselman III	Charles C.	M.I.T.	617-253-7902
Crabbs	Robert	Research Support Instruments	410-785-6250

DISCOVERY WORKSHOP ATTENDEES

Last Name	First Name	Affiliation	Phone
Crisp	David	JPL	818-354-2224
Cruz	Manny I.	TRW, Inc. Federal Systems Div.	310-813-0261
Danielson	Ed	Caltech	818-356-6861
Dasch	Pat	SAIC	202-479-0750
Delamere	Alan	Ball Aerospace	303-939-4243
Dermott	Stan	U. Florida	904-392-3748
Dessler	Alex	Rice University	713-527-4045
DiBiasi	Lamont	Fairchild Space	301-428-6610
Dickinson	Richard	JPL	818-354-6406
Dickinson	Tammy	NASA HQ	202-358-0292
Dowling	Kevin	Carnegie Mellon Univ.	412-268-8830
Dudenhoefer	James E.	NASA-LeRC	216-433-6140
Duxbury	Tom	JPL	818-354-4301
Eckstrom	William	Upslope Inc.	303-772-1197
Economu	Tom	U. Chicago	312-702-7829
Edwards	Charles D.	JPL	818-354-4408
Edwards	Bradley C.	Los Alamos National Lab.	505-667-8896
Elachi	Charles	JPL/Caltech	818-354-5673
Elphic	Rick	Los Alamos National Lab.	505-667-3693
Emmerling	Bob	Allied - Signal Aerospace	310-512-1308
Englert	Peter	San Jose State Univ.	408-924-4820
Esposito	Larry W.	LASP- Univ. Colorado	303-492-7325
Farmer	Crofton	San Juan Institute	714-240-2010
Farquhar	Robert W.	APL, Johns Hopkins Univ.	301-953-5572
Fay	Theodore	McDonnell Douglas, Space Systems	714-896-5860
Feldman	Paul D.	Johns Hopkins Univ.	410-516-7339
Florence	Dwight	GE Aerospace	215-354-2717
Fox	Ken	U. Tennessee	301-314-9124
Freitag	Joe	TRW Inc.	310-812-2371
Friedlander	Alan	SAIC	708-330-2518
Ftaclas	Christ	Hughes Danbury Optical Systems	203-797-6448
Fujiwara	Akira	ISAS (Japan)	0427-51-3911
Gamber	Terry	Martin Marietta	303-977-5988
Garcia	Frank	IBM - FSC	713-282-7660
Giberson	Gene	Consultant	818-790-2289
Girard	Michael	JPL	818-354-3216
Goldin	Dan	NASA Administrator	202-453-1010
Goody	Richard	Harvard University	818-354-5164
Graf	Paul	Ball Aerospace	303-939-5538
Gruntman	Michael	U. Southern California	213-740-6334
Gulkis	Samuel	JPL	818-354-5708
Hansen	Elaine R.	U. Colorado	303-492-3141
Hansen	Candice	JPL	818-354-7675
Hardin	Mary	JPL Public Information Office	818-354-5011
Harris	Al	JPL	818-354-6741
Head	James W.	Brown University	401-863-2526

DISCOVERY WORKSHOP ATTENDEES

Last Name	First Name	Affiliation	Phone
Helleckson	Brent	U. Colorado	303-492-2746
Hickman	Mark	NASA/LeRC	216-977-7105
Hirshfield	Edward	Space Systems/LORAL	415-852-5805
Horan	Andrew	Orange County Register	714-498-1270
Horn	Linda	JPL	818-354-1647
Hörz	Friedrich	NASA-JSC	713-483-5042
Housley	Robert M.	Rockwell Science Center	805-373-4221
Hunten	Don	U. Arizona	602-621-4002
Jackson	William M.	UC Davis	916-752-8995
Janssen	Mike	JPL	818-354-7247
Jensen	Elsa	UC San Diego	619-534-7840
Johnson	Bob	U. Virginia	804-924-3244
Kawaguchi	Junichiro	ISAS/ Japan	81-427-51-3963
Kerridge	John	UCLA/UCSD	619-534-0443
Kerridge	Stuart	JPL	818-354-0899
Killeen	T.L.	U. Michigan	313-747-3435
Klusendorf	Roy	Astro Aerospace	805-684-6641
Knight	Tony	Martin Marietta	303-971-9002
Knocke	Phillip C.	JPL	818-354-3915
Koch	David	NASA/ARC	415-604-6548
Krimingis	Stamatios M.	APL- Johns Hopkins Univ.	301-953-5287
Krotkov	Eric	Carnegie Mellon Univ.	412-268-3058
Kumer	John B.	Lockheed Palo Alto	415-424-2327
Lal	Devendra	UC San Diego	619-587-1535
Lane	Arthur L.	JPL	818-354-6186
Langevin	Yves	Inst. D'Astrophysique Spatiale	33-169-858-681
Langford	John	Aurora Flight Sciences	703-369-3633
Lapins	Uldis	Hughes Aircraft Co.	301-364-4579
Lawrence	George	LASP/ Colorado Univ.	303-492-5389
Lee	Gentry	Consultant	214-625-3026
Lillie	Charles F.	TRW	310-814-3774
Limaye	Sanjay S.	U. Wisconsin-Madison	608-262-9541
Lindberg	Robert	APEX	703-802-8005
Lissauer	Jack	SUNY Stony Brook	805-893-4111
Lofgren	Gary	NASA/JSC	713-483-6187
Lopes	Rosaly	JPL	818-393-0996
Luhmann	Janet	UCLA	310-825-1245
Lundberg	John	U. Texas	512-471-5863
Lyons	Daniel T.	JPL	818-393-1004
Maag	Carl	SAIC	818-335-6888
Malin	Mike	Malin Space Sciences Sys.	619-552-6980
Martin	Jim	Consultant	813-324-5481
Martin	Warren L.	JPL	818-354-5635
Mastal	Edward	Dpt. Energy, Special Appl	301-903-4362
McCarthy	John	Hughes	301-364-4579
McCleese	Daniel J.	JPL	818-354-2317

DISCOVERY WORKSHOP ATTENDEES

Last Name	First Name	Affiliation	Phone
McDonnell	Tony	U. Kent, Canterbury U.K.	440227764000
McEwen	Al	USGS	602-556-7194
McLoughlin	Frank	AeroAstro Corp.	415-940-1637
Mendillo	Michael	Boston University	617-353-5990
Metzger	Albert	JPL	818-354-4017
Meurer	Robert H.	Orbital Sciences Corp.	703-803-2033
Meyer	Michael	Exobiology/LESC	202-863-5257
Meyers	James F.	McDonnell Douglas Aerospace	714-896-3473
Miller	Sylvia	JPL	818-354-2947
Moore	James	NASA/GSFC	301-286-6248
Morrison	David	NASA Ames	415-604-5029
Morton	Oliver	The Economist	0114471-839-916
Moses	Stewart L.	TRW Space Science	310-812-0075
Muhleman	Duane O.	Caltech	818-356-6112
Mulholland	J. Derral	POD Associates, Inc.	505-243-2287
Murray	Bruce	Caltech	818-356-3780
Nash	Doug	San Juan Institute	714-240-2010
Nelson	Robert	JPL	818-354-1797
Neugebauer	Marcia	JPL	818-354-4321
Neukum	Gerhard	DLR/ Germany	8153-28731
Nichols	D. Bruce	Westinghouse	410-765-3216
Nishioka	Ken	NASA-ARC/SETI	415-604-0103
Niu	William	Perkin Elmer Corp.	714-593-3581
Nock	Kerry	JPL	818-354-2153
Norris	Henry	JPL/ Retired	805-482-2621
Ocampo	Adriana	JPL	818-393-1080
Orton	Glenn	JPL	818-354-2460
Paddack	Steve	NASA/GSFC	301-286-9653
Paige	David A.	UCLA	310-825-4268
Peale	Stan	UC Santa Barbara	805-893-2977
Penzo	Paul A.	JPL	818-354-6162
Perez	Ernest F.	Consultant Space Systems Loral	714-637-5067
Pichkhadze	Konstantin	Babakin Institute	575-56-42
Pietila	P.W.	McDonnell Douglas	714-896-1933
Pilcher	Carl	NASA HQ	202-358-0290
Plescia	Jeff	JPL	818-354-2046
Polyakov	Andrei	Babakin Institute	5739192
Pyle	John	NASA/GSFC	301-286-7531
Quaide	Bill	SAIC	703-978-2341
Rand	Mide	UC San Diego	619-534-7840
Randolph	James	NASA HQ, Space Physics Div.	202-358-0889
Ravine	Michael	IGPP/SIO/UCSD	619-534-8813
Reedy	Robert C.	Los Alamos Nat'l Lab.	505-667-8366
Reinert	Richard	Ball Aerospace Systems Grp.	303-939-5953
Richards	B.	Boeing & Space Group	206-773-7003
Ridenoure	Rex	JPL	818-354-2740

DISCOVERY WORKSHOP ATTENDEES

Last Name	First Name	Affiliation	Phone
Rider	David	JPL	818-354-3776
Rodgers	David H.	JPL	818-354-5576
Romig	Joe	Radiophysics, Inc.	303-477-9524
Rosen	Cecil	NASA Aeronautics	202-453-1010
Rosiak	Gary T.	TRW	310-812-0141
Russell	C.T.	UCLA	310-825-3188
Saunders	R. Stephen	JPL	818-393-0877
Sauret	Tom	NASA Executive Officer	202-453-1010
Schneider	Alan	UC San Diego	619-534-3181
Schneider	Stanley	McDonnell Douglas Corp.	714-896-5860
Scott	David R.	SST, Inc.	310-312-9540
Scott	David H.	USGS	602-556-7188
Shemansky	D.E.	USC	213-740-7184
Shoemaker	Eugene M.	U.S. Geological Survey	602-556-7181
Simon	Bob	NASA HQ	202-453-1010
Sizemore	Ken	NASA/GSFC	301-286-5108
Skillman	David R.	NASA/GSFC	301-286-5253
Smith	Wm. Hayden	Washington University	408-624-4644
Smith	David	Space Studies Board	202-334-3477
Smythe	William D.	JPL	818-354-3612
Soderblom	Larry	USGS	602-556-7018
Spilker	Thomas R.	JPL	818-354-1868
Spudis	Paul	Lunar & Planetary Inst.	713-486-2193
Staehle	Robert L.	JPL	818-354-1176
Stanford	Kerry	Polar Ice Coring Office	907-474-5585
Stern	S. Alan	Southwest Research Inst.	512-522-5127
Stevenson	Steve	NASA/ LeRC	216-977-7087
Stewart	A.	Boeing	206-773-9774
Stigdon	Stan	Westinghouse	410-993-7773
Stofan	Ellen	JPL	818-393-0994
Svitek	Tomas	APEX/SeaStar	703-802-8169
Sweetnam	Don	JPL	818-354-7771
Swenson	Byron L.	SAIC	415-960-5904
Sykes	Mark V.	U. Arizona	602-621-5381
Tanner	William G.	Baylor University	817-755-3879
Taylor	F.W.	Oxford University	44-0865-272903
Terrile	Richard	JPL	818-354-6158
Thunen	John	Santa Barbara Res. Center	805-562-7108
Travis	Elmer	Swales & Associates, Inc.	301-595-5500
Uesugi	Kuninori	ISAS, Japan	81-427-59-4241
Utterback	Nyle G.	Von Hoerner U. Sulger, GMBH	805-687-2049
Veverka	Joseph	Cornell University	607-255-3507
Vilas	Faith	NASA JSC	713-483-5056
Vincent	Mark A.	JPL	818-354-3224
Vorder Bruegge	Richard W.	SAIC	202-479-0750
Waite	Hunter	SWRI	512-522-3493

DISCOVERY WORKSHOP ATTENDEES

Last Name	First Name	Affiliation	Phone
Wallace	Richard A.	JPL	818-354-2797
Waltz	Donald M.	ILC Dover, Inc.	714-472-0500
Warner	Darrell V.	Wallwork-Warner	215-647-2851
Warwick	Jim	Radiophysics, Inc.	303-447-9524
Wdowiak	Thomas J.	U. Alabama-Birmingham	205-934-4736
Weissman	Paul	JPL	818-354-2636
Wiens	Roger	Caltech	818-356-6155
Williams	Pete	Lockheed	408-742-5047
Willis	Paul	JPL	818-354-6998
Willoughby	Alan J.	Analex Corp.	216-977-7077
Wiskerchen	Michael	UCSD	619-534-5869
Wolf	Aron	JPL	818-354-6917
Wright	Frank	JPL	818-354-5690
Yano	Miles	Irvin Industries Inc.	714-662-1400
Zook	Herb	NASA/ JSC	713-483-0123
Zuppero	Tony	Idaho Nat. Engineering Lab.	208-526-5382

MISSION CONCEPT CATEGORIES
(Subgroup Assignment Based on Key Sci. Objectives of Each Concept)
Doug Nash San Juan Institute 11/9/92

A. ATMOSPHERES [14]

Terrestrial Planets	
Venus	4, 12, 16, 17, 38, 98, 99
Mars	3, 49, 51, 79, 80, 92
Giant Planets	74

B. DUST, FIELDS, PLASMA [15]

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Cometary Dust	78
Meteors, Micrometeroids	7
Solar Wind	9
Planet Fields, Particles, Plasmas, etc.	
Mercury	60
Venus	35, 37
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Earth	39
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C. SMALL BODIES [23]

Comets	
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Coma	14, 23, 46
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Phobos	75, 100
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D. SOLID BODIES [21]

Terrestrial Planets	
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Venus	42, 55, 81
Mars	83, 86
Moon	43, 44, 58, 64, 65, 72, 87, 94, 97

CONCEPTS WITHDRAWN [27] 8, 10, 19, 21, 25, 27, 30, 31, 33, 36, 41, 45, 48, 50, 56, 57, 59, 62, 63, 67, 68, 69, 70, 71, 82, 89, 91

SUMMARY OF CONCEPTS (1-PAGE) SUBMITTED <u>BY INSTITUTIONS</u> OF P.I.
10/22/92

JPL	[15]	2, 4, 5, 12, 15, 34, 38, 40, 43, 44, 53, 80, 81, 85, 100
U. COLO	[5]	17, 26, 58, 63, 97
CALTECH	[4]	9, 46, 52, 54
SWRI	[3]	29, 35, 90
LANL	[3]	20, 60, 75
GSFC	[2]	65, 66
NASA/ARC	[2]	23, 61
UCLA	[2]	37, 83
U. WISCON.	[2]	3, 49
JSC	[2]	1, 28
USGS	[2]	71, 77
WASH. U.	[2]	72, 73
U. ARIZONA	[2]	32, 76
CORNELL	[2]	18, 47
NASA/LEWIS	[2]	39, 64
MISC.(1 ea.)	[25]	6,7,11,13,14,16,22,24,42,51,55,74,78, 79,84,86,87,88,92,93,94,95,96,98,99

Synopses of Discovery Mission Concepts

C #1 **Cosmic Dust Collection Facility**

Friedrich Hörz - NASA-JSC

This proposal is for an instrument facility on Space Station Freedom and not a complete mission concept. Its objective is to determine the composition and trajectories of cosmic dust particles.

C #2 **Jupiter Polar Orbiter**

Glenn Orton - JPL

The goal of the JPO mission is to determine processes taking place in the magnetic field and charged particle environment which influence high latitude neutral atmosphere and ionosphere. It will use a small spinning spacecraft launched by a Delta II vehicle. The JPO spacecraft will be placed in a dawn-dusk, polar, ~ 90-day elliptical orbit with initial perijove of $10R_J$, raised after half an orbit to 15 R_J to avoid damaging radiation exposure. Toward the end of the nominal 18-month mission, the perijove could be lowered to 5 R_J to make in situ measurements of Io's torus.

C #3 **Martian Climate Variability - A Microsat Approach**

Verner Suomi - University of Wisconsin—Madison

This mission would perform a systematic survey of the atmosphere of Mars using the radio occultation technique. A constellation of 4 microspacecraft would be placed by a common carrier into a single orbit plane in a sun synchronous, near-polar orbit. The mission is designed to be compatible with a Taurus XL/S launch vehicle. No launch date is defined.

C #4 **Venus Multiprobe Mission (VMPM)**

Richard Goody - Harvard University

VMPM involves the placement of 14 small entry probes over one hemisphere of Venus to profile the atmosphere structure from 65 km altitude to the surface, measuring winds in three dimensions as well as temperature and pressure. A single payload element, an atmosphere structure package, together with a local oscillator for accurate DVLBI radio tracking from Earth accomplishes this purpose. Probe design is patterned after the Pioneer Venus small probe, while the carrier spacecraft has Earth orbital heritage.

C #5 **A Comet Impact Mission (CIM)**

Marcia Neugebauer - JPL

Cometary nucleus flyby mission occurring near perihelion. An impactor system is detached prior to encounter and is impacted just preceding flyby. The impactor provides kinetic impact energy to produce a large crater and ejecta which are observed by trailing spacecraft and remotely from earth.

C #6 **SMACS: Small Missions to Asteroids and Comets**

Michael Belton - National Optical Astronomy Observatories

SMACS involves separate launches of four small spacecraft on Pegasus XL boosters in the 1998-2000 time frame to a primitive object (2100 Ra-Shalom, a C-object); a highly evolved igneous object (1986 DA, a M-type); a moderately active cometary nucleus (P/Finley); and an extinct or dormant comet nucleus (3200 Phaethon, F-type).

C #7 **Ultraviolet Imaging Spectroscopy of Meteors**

Thomas Wdowiak - University of Alabama-Birmingham

Concept for analysis of middle to far ultraviolet spectral data of meteoric debris of cometary origin using the QuickStar spacecraft bus (derivative of the SDIO LOSAT-X spacecraft) launched to an equatorial or polar orbit about Earth.

C #9 **Solar Wind Sample Return Mission**

Don Burnett - Caltech

A sample return mission aimed at collection/analysis of solar wind constituents. Mission will fly outside Earth's magnetosphere, expose materials to the solar wind for a period of 2 years, and return the exposed materials to Earth for analysis. Although costs are estimated for a dedicated mission concept, the possibility of performing this mission in a piggy-back mode exists.

C #11 **Asteroid Sample Return Mission**

Robert Housley - Rockwell International

A "simple, unadorned" mission to rendezvous with an S-type or C-type asteroid, collect at least one kilogram of surface samples, and return them to Earth via aerocapture to LEO followed by entry and parachute descent to a non-water landing site.

C #12 **Venus Orbiter - Deep Atmosphere Temperature Sounder (DATS)**

Samuel Gulkis - JPL

DATS is a Discovery class mission designed to gather synoptic global data on the variability of the deep atmosphere of Venus from the surface to about 50 km altitude. The proposed experiment has the potential of providing temperature profile information, sulfuric acid vapor content, and sulfuric acid cloud motions on a global scale.

C #13 **Earth-Orbital UV Jovian Observer**

Paul Feldman - John Hopkins University

The proposed spacecraft will carry a single scientific instrument, a spectrographic imaging telescope, to an orbit about the Earth-Sun L_1 point. Nine months of the proposed one-year mission lifetime is dedicated to observation of the Jovian system.

C #14 **Comet Coma Rendezvous Sample Return (CCR-SR)**

Ben Clark - Martin Marietta

Cometary nucleus rendezvous at or near perihelion. Collection of particulate and gas samples followed by direct return of samples aboard an entry vehicle with recovery on the Earth's surface. Requires a foreign partner to provide Earth return system.

C #15 **Mercury Polar Flyby**

Paul D. Spudis - LPI

Proposal to send a spacecraft similar to Mariner 10 to Mercury on a flyby trajectory that is 2:1 resonant with Mercury in order to provide one or two subsequent returns. The objective is to characterize and study Mercury's polar caps and to complete the imaging reconnaissance of the planet.

C #16 **Venus Atmospheric Dynamics Imaging Radiometer (VADIR)**

F.W. Taylor - Oxford University

VADIR is a mission to study the dynamics of the atmosphere of Venus by producing thigh space and time resolution images of the motions of features in the atmosphere at all levels from the surface to 90 km altitude.

C #17 **Venus Composition Probe**

Larry W. Esposito - University of Colorado

Launched directly to Venus in 2001 or 2002 by a Titan II or Delta II vehicle, this single "free-flyer" probe enters Venus atmosphere in daylight after a 4-month flight to measure atmospheric structure and composition from 75 to 42 km altitude on parachute descent followed by continued IR measurements to the surface in a separable pressure vessel. Design/hardware heritage from Pioneer Venus & Galileo probes, and MESUR-Pathfinder.

C #18 **Comet Nucleus Tour - CONTOUR Values**

Joseph Veverka - Cornell University

Flyby of three comets (Encke, Tempel-1, d'Arrest) on a single 5-year mission launched in August 2003 by a Delta II (7925), employing multiple Earth gravity assists for retargeting purposes. Science focus is on nucleus structure, composition, and processes with data obtained from 3 instruments: imager, dust analyzer, and neutral/ion mass spectrometer.

C #20 **CHEMIN (Chemistry and Mineralogy using combined X-ray Fluorescence and X-ray Diffraction)**

David Blake - NASA Ames

The goal is to land an X-ray diffraction (XRD)/X-ray fluorescence (XRF) instrument on the surface of Mars (or other solid solar system body) to perform chemical and mineralogical analysis of surface material. X-ray diffraction analysis has never been performed on any previous space mission. This is not a complete mission proposal.

C #22 **Spatio-Temporal Monitoring of Space Debris**

J. Derral Mulholland - POD Associates, Inc.

Concept to map spatial and temporal characteristics of the small-scale space particulate environment in the space beyond geosynchronous orbit, even into the trans-lunar domain, by flying a capacitor-type micrometeoroid impact detector as secondary payload on other Discovery spacecraft. Not a stand alone mission concept.

C #23 **Cometary Coma Chemical Composition (C4) Mission**

Glenn C. Carle - NASA ARC

Cometary nucleus rendezvous at or near perihelion followed by 100 days of scientific operations. At least 4 comet targets appear feasible with Temple 1 as primary target for a launch in 1999. Coma sampling by modified CIDEX and NGIMS. Spin-stabilized, solar-powered spacecraft.

C #24 **A SPACE Experiment**

Wm. Hayden Smith - Washington University

Space Particle Analysis by Collisional Excitation (SPACE). To infer the composition of small particles in earth orbit or various locations in space by observing emitted light from particle impact. This is an instrument proposal without detailed mission or spacecraft information.

C #26 **The Small Comet and Interplanetary Hydrogen (SCIH) Discovery Mission and Ultraviolet Solar System Observer (UVSSO)**

John Brandt - University of Colorado

This mission would (1) determine the spatial density, orbital characteristics, and physical properties of small comets (water-ice sublimating bodies with radius < 1 km) and (2) continue the role of IUE (a mission launched in 1978) as a follow-on activity to the cometary phase of the mission. The three-axis stabilized satellite, instrumented with narrow and wide field UV imagers and a high-resolution telescope spectrograph, would be launched by Pegasus XL into low Earth orbit in 1999 for a nominal TBD years of operation.

C #28 **IPSIT (Inner Planet Spectrographic Imaging Telescope)**

Faith Vilas - JSC

Earth orbiting satellite designed primarily to observe and study the composition and distribution of Mercury's surface mineralogy and tenuous atmosphere. Also, observations of other inner solar system objects (e.g. Venus and Mars, NEA's, comets) can be made during periods when Mercury can't be observed. The viewing instrument is a 50 cm telescope with UV, visible, and IR spectrographs. The planned lifetime of IPSIT is 5 years.

C #29 **Comet Activity Probe (CAP)**

James Burch - Southwest Research Institute

Cometary nucleus rendezvous near perihelion. Observations of nucleus and coma continue to 3 AU. At least 4 targets appear feasible with Temple 1 as primary target for a launch in 1999. Imaging, dust detection, charged particle, and field observations. Spin-stabilized, solar-powered spacecraft.

C #32 **Rendezvous with Earth Approaching Asteroids (REAAct)**

Daniel Britt - University of Arizona

Four spacecraft launched in pairs one year apart by the Delta II are placed into an elliptical lunar parking orbit to await discovery of new objects approaching Earth, thereafter to be sent to rendezvous. Backup missions to known objects available as option. Science instruments are a CCD imager, IR point spectrometer, and 3 alpha-proton-xray spectrometers that are landed on asteroid surface.

C #34 **Hermes Global Orbiter—A Mission to Mercury**

Robert Nelson - JPL

This mission to the planet Mercury will perform remote sensing observations of the planet's surface, its atmosphere, and its magnetosphere. The payload consists of a telescope system for passive and active photopolarimetry, a UV spectrometer, and a magnetometer. After orbit insertion the nominal mission lifetime is one Earth year.

C #35 **A Planetary/Heliospheric Reconnaissance of Dynamics: Ionosphere, Thermosphere, and Exosphere (APHRODITE)**

J.H. Waite, Jr. - Southwest Research Institute

APHRODITE is a Discovery class mission which will focus on the exploration of Venus thermosphere, exosphere and ionosphere. Primary objectives: (1) characterize the neutral wind systems in the upper atmosphere and (2) characterize the dynamics of the plasma flow in the ionosphere and nearby solar wind. The spacecraft is placed into an elliptical polar orbit at Venus.

C #37 **Venus Cloud Structure and Dynamics Lightning Observations Upper Atmospheric Loss Processes Discovery (CLOUD) Mission**

Chris Russell - UCLA

The principal goals of the Venus CLOUD mission are to study the structure and dynamics of the Venus Clouds using the nightside thermal IR to backlight clouds from below, to use lightning as a proxy for vertical convection and thereby determine where strong vertical convection occurs in the clouds, to evaluate the importance of lightning in the chemistry of the Venus atmosphere and to determine the accretion rate and loss of atmosphere of Venus.

C #38 **Venus 4-D Discovery Mission**

K. Baines - JPL

Investigate the dynamics, chemistry, and thermal structure of the Venus atmosphere, using three instruments (NIMS, CCD camera, Thermal IR scanner), and a modified Earth-orbiting bus design. Will utilize a 45°, 33,400 km circular orbit.

C #39 **Magnetospheric Mapping and Current Collection in the Region from LEO to GEO**

Mark Hickman - NASA-LeRC

An in-house center project to fly a kilowatt-class solar electric propulsion vehicle with instrumentation to support plasma current collection and magnetospheric mapping from a highly inclined, low altitude Earth orbit through the Van Allen radiation belts and plasma environment to a moderately inclined geosynchronous orbit.

C #40 **SOCCER Pathfinder**

Paul Weissman - JPL

This is a concept for a U.S./Japan dual spacecraft Kopff comet flyby and coma sample return mission. The U.S. built and launched s/c (11/01 LD) would first serve as a navigational pathfinder for the Japanese s/c (which would collect and return samples to Earth) and then be retargeted for a flyby of Icarus in 2005.

C #42 **Venus Geophysical Network Pathfinder**

Michael Malin - Malin Space Science Systems

A proof-of-concept, the Venus hard lander measures and returns surface geophysical data for 1 year. Payload consists of seismometer, meteorology sensors, magnetometer, and surface imager. Concept requires RTG-powered active refrigeration of pressure vessel, which contains all electronics. Sensor heads of several instruments will be mounted outside the dewar.

C #43 **Lunar Interior Explorer Mission**

Jeff Plescia - JPL

The Lunar Interior Explorer will provide the same type data provided by the Japanese LUNAR A mission (lunar seismic, heat flow, and core structure) but at a more comprehensive/global level.

C #44 **Lunar Geophysical Explorer (LGE)**

Jeff Plescia - JPL

The LGE concept is a lunar orbiter mission proposed to address the LEXSWG science measurement priorities not directly measured by Lunar Scouts I and II. These include gravity, topography, remnant magnetics, heat flow and the lunar atmosphere. The proposed spacecraft platform is similar to that proposed by Boeing for the Scouts (I and II).

C #46 **Flyby Sample Return via SOCCER**

Arden Albee - California Institute of Technology

This Flyby Sample Return mission concept is the sample collection portion of the Japanese SOCCER Project. The baseline mission presumes an August 2000 launch to comet Finley, with Earth return occurring in August 2004. The Shuttle is assumed to retrieve the payload.

C #47 **Mainbelt Asteroid Exploration/Rendezvous (MASTER)**

Joseph Veverka - Cornell University

At least one of two complementary alternative missions with identical payloads, launched in 2001 or 2003, would rendezvous and then orbit the mainbelt asteroids Iris or Vesta. The 3-instrument payload consists of an imager, IR imaging spectrometer, and gamma ray spectrometer. A 3-axis stabilized spacecraft utilizing solar power and bipropellant thrusters is a new Class C design configuration with significant subsystem heritage.

C #49 **Mars Operational Environmental Satellite (MOES)**

Sanjay Limaye - University of Wisconsin (UW)—Madison

MOES, over a single Martian year, would investigate the weather systems and diurnal behavior of Martian atmosphere and surface by obtaining up to 8 times per sol coverage of the tropics and mid-latitudes. The single A/B Class spacecraft would be launched by a Delta II launch vehicle and destined for a 25 degree inclination, 216 min, 2250 km circular orbit with a two instrument payload.

C #51 **Mars Atmospheric Aircraft Platforms**

John Langford - Aurora Flight Sciences Corp.

Concept to develop small Mars aircraft and fly it on the MESUR mission. Aircraft would conduct visual imaging or other science investigations.

C #52 **MIRROR (Mercury Imaging and Radar Ranging Orbital Reconnaissance)**

Duane O. Muhleman - Caltech

The proposed concept would place a small spacecraft in orbit at Mercury to return the first global coverage of the entire surface and precisely locate and map the extent of the polar ices. The concept utilizes an E-VVMM-M trajectory with a lightweight production spacecraft that supports a Delta II launch. The payload would be scaled down to two instruments and managed in a low cost university mode at Caltech.

C #53 **Mercury Mapping Orbiter Mission**

Albert E. Metzger - JPL

This proposal describes a Mercury orbiter mission utilizing a unique lightweight and low cost spacecraft carrying a payload complement of four instruments consisting of a UV/visible camera, GRS, XRFS, and a magnetometer. The primary objective is planetary observation; solar, heliospheric and celestial data would be sought only as instruments and mission lend themselves to that secondary objective.

C #54 **Pluto/Charon Flyby Mission**

B. Murray - Caltech

Battery-powered fast flyby of Pluto and Charon performs a reconnaissance mission with imaging based on the Mars Observer camera, and a radio atmospheric occultation experiment. Meet cost objective with a small staff and simplified spacecraft design.

C #55 **Discovery Venera Surface-Atmosphere Geochemistry Experiments (SAGE)**

James Head, III - Brown University

Concept is to launch a Venera-class lander to a designated target of high scientific interest on Venus, instrumented to measure lower atmosphere constituents and surface geochemistry and mineralogy, as well as surface geology.

C #58 **Lunar Interior Structure**

Peter Bender - University of Colorado

A mission to place three microwave transponders on the front side of the lunar surface in order to improve dynamical studies of lunar rotation and tidal distortion by two orders of magnitude. These capabilities performed over a two-year period should significantly improve our understanding of the interior structure of the moon providing important constraints on the formation and tidal evolution of the Earth-Moon system.

C #60 **A Mercury Interior, Surface & Environment Mission Concept**

Robert C. Reedy - LANL

Discovery Program to provide/develop fields and particles instruments to be carried by a Mercury orbiter(s) in mission based on Mercury Orbiter Science Working Team concept presented in NASA TM-4255. Instruments would include a magnetometer, ion mass spectrometer, electron reflectometer, and neutron detector.

C #61 **Frequency of Earth-sized Planets (FRESIP)**

William J. Borucki - NASA ARC

Telescope (1.2 m) in high Earth orbit to conduct photometric survey of fields of 6000 F, G, and K type stars within single FOV and 90-560 parsec to detect transits of Earth-sized planets. Confirmation of transit occurs for three observed transits, thus mission period is about three years in length.

C #64 **Combined Lander and Instrumented Rover (CLIR)**

Lee Mason - LeRC

A lunar rover 14-day near-side mission is proposed using an integrated walking lander/rover concept. The concept is simple and very lightweight, with a total payload mass within the capability of the OSC Taurus launch vehicle. The rover is controlled semi-automatically and has an advertised traversal range of 10 km during its 2-week primary mission.

C #65 **Koati: Lunar Polar Orbiter**

Bruce Bills - NASA GSFC

A one-year lunar polar orbiter mission is proposed to obtain global topographic and gravity field maps of the moon support by contextual global imaging. The mission concept is based on GSFC's Lightsat spacecraft requiring a Taurus class small expendable launch vehicle and mission operations conducted through a Wallops Island ground station.

C #66 **Mallcu: A Mercury Polar Orbiter Mission**

Bruce Bills - NASA GSFC

The Mercury Polar Orbiter will perform the first global survey of Mercury, characterizing the planet's surface geology, topography, and gravity and magnetic fields.

C #72 **Lunar Ultra-violet Infrared Spectrometer**

Wm. Hayden Smith - Washington University

Placement of a spacecraft carrying the lunar ultra-violet infrared spectrometer in a 100 km altitude polar orbit, enables accomplishment of the primary objective—to obtain accurate, detailed global maps of geochemical and mineralogical properties of lunar surface materials.

C #73 **The Comet Nucleus Observer (CNO)**

Wm. Hayden Smith - Washington University

This is essentially a proposal for an instrument to do spectral imaging and mapping of a comet nucleus and innermost coma during a rendezvous mission. No details of mission or carrier spacecraft provided.

C #74 **RSAM (Radio Science & Astronomy Mission): Giant Outer Planet Orbiters**

Len Tyler - Stanford University

A radio science orbiter is proposed for intense study of any of the giant outer planets to gain new information on atmospheres, interiors, rings, and satellites. The spacecraft's orbital tour at a target planet would consist of successive 1 month orbits for a total duration of 1 year to achieve global coverage.

C #75 **The Prospector Mission**

Bradley Edwards - LANL

The Prospector mission would conduct geologic and geochemical composition of solar system objects using advanced instrument capabilities. In this proposal a Delta II 7925 launch vehicle would send a s/c to Phobos with high resolution x-ray florescence imager (elemental abundances) and visible/near IR spectrometer (mineralogy) instrumentation.

C #76 **Comet Nucleus Penetrator**

William V. Boynton - University of Arizona

Deployment of a Penetrator into the nucleus of a comet following rendezvous. At least three comet targets appear feasible with SW-3 as primary target with launch in 2001. Penetrator similar to CRAF Penetrator. Penetrator augmented by module for delivery. Data relay direct to Earth.

C #77 **Near Earth Asteroid Returned Samples (NEARS)**

Eugene Shoemaker - U.S. Geological Survey

Sample acquisition and return to Earth reentry/landing of a set of small samples from six different sites on the surface of a NEA target body. Proposed to meet cost objectives via significant hardware heritage from NEAR spacecraft and GE reentry capsule.

C #78 **Comet Coma Sample Return (CCRS)**

W. Merle Alexander - Baylor University

Comet nucleus flyby near perihelion with closest approach < 100 km with return trajectory to earth. Coma samples collected by four different means, impact parameters are recorded, and plasma components are measured. Sample is propulsively captured into Earth orbit and retrieved by Shuttle.

C #79 **A Mars Upper Atmosphere Dynamics, Energetics and Evolution Mission (MUADEE)**

Timothy Killeen - University of Michigan

MUADEE is a Delta-launched spinning spacecraft destined for a highly elliptical 63.4 degree inclination mission. A science complement of 7 remote sensing and in situ instruments is planned to explore the upper atmosphere and ionosphere (60-120 km).

C #80 **"The Little Dipper" Mars Aeronomy, Gravity, and Radio Science**

Daniel T. Lyons - JPL

The "Little Dipper" is a concept for an orbiting atmospheric probe which will study neutral gas composition and density of the Mars atmosphere. In addition, as the orbit of the probe decays from highly elliptical to near circular the gravity field of Mars will be measured. Radio occultation experiments and particle/surface interaction experiments are also described.

C #81 **Venus Interior Structure Mission (VISM)**

Ellen R. Stofan, R. Stephen Saunders - JPL

The goal of this project is to study the interior of Venus utilizing seismometry. The mission employs a PVO-type spacecraft with three probes, each containing a seismometer. Each lander and seismometer are capable of operating for greater than 30 days on the Venus surface, transmitting data back to an orbiting platform for transmittal to Earth.

C #83 **The Mars Polar Pathfinder**

David A. Paige - UCLA

Subsurface exploration of the northern Martian polar cap by a modified MESUR Pathfinder lander system. Landed payload includes radar for subsurface layering to 5 km, thermal probe to measure various ice quantities to 100 m, and subsurface camera deployed by auger to 50 cm. Launch in 2002.

C #84 **A Proposal for Atmospheric Exploration of the Moon**

Donald Shemansky - University of Southern California

The proposed experiment is designed to measure the content and morphology of the lunar atmosphere. The purpose is to determine source processes and to utilize the Moon as a detector of small objects entering the inner solar system.

C #85 **Io Mapper**

William Smythe - JPL

One year study of Io's volcanism using a single imaging instrument that improves on Galileo's spatial and spectral capability: a combined visual/infrared camera and radiometer. Proposal requires prior development of the Pluto spacecraft to meet the Discovery cost goal.

C #86 **Mars Gravity Measurement/Surface Penetrator Assembly Mission**

Wallace T. Fowler - University of Texas

Proposal for three optional Mars mission options to obtain high precision gravity models and subsurface water and elemental composition measurements. Options involve gravity mapper and 3 penetrators, 2 small low-orbit orbiters and 2 penetrators, or option 2 augmented by MO signals.

C #87 **Lunar Lava Tube Explorer**

Red Whittaker - Carnegie Mellon University

An integrated, self-sufficient lander/rover will traverse hundreds of kilometers, perform a variety of scientific experiments, map the surface and subsurface, and transmit high-definition images of the lunar landscape.

C #88 **Solar System Exploration Cryogenic Telescope (SSECT)**

John Kumer - Lockheed Palo Alto Research Lab

This 1-year mission would deploy a cryogenically cooled telescope and spectrometer in GEO to investigate a wide range of cometary phenomena and examine asteroids and small satellites. The 881 kg spacecraft would be lofted to this orbit by a Delta 7925 launch vehicle in 2001 (other launch opportunities available).

C #90 **Chiron Discovery Flyby**

S. Alan Stern - Southwest Research Institute

This proposal plans to send the spare Pluto Flyby spacecraft to fly by the distant comet 2060 Chiron in order to address objectives relating to cometary science, Chiron' size, shape, polar obliquity, atmosphere, surface morphology, surface composition, internal structure, and surface activity.

C #92 **None**

Jacques E. Blamont - University of Paris, CNES, and JPL

Describes a redistribution of responsibilities for Mars exploration including U.S. purchase of Russian hardware and international cooperation in the formation of a joint U.S./Soviet technical team. This is not a mission proposal, and does not meet the program requirements for a Discovery Mission concept description.

C #93 **SIPAC (Satellite for Imaging Planetary Alkaline Comas)**

Michael Mendillo - Boston University

This is an Earth orbiting mission to study the tenuous extended atmosphere of Mercury, the Moon, and Jupiter. The proposed spacecraft is a modified Ball QuickStar satellite. A Pegasus launch vehicle would be required to put the s/c in the desired orbit. The science payload consists of a single instrument (telescope optics and three CCD units).

C #94 **Ulysses - A Return to the Hadley Apennine**

David Scott - Scott Science and Technology, Inc.

The Ulysses mission's primary objective is to prove the concept of conducting Apollo-type planetary exploration missions with low-cost, flexible, robust hardware and operations. Two microrovers will explore selected surface features in the vicinity of the Apollo 15 site.

C #95 **Polar Orbiters for Giant Planet Exploration**

James Warwick - Radiophysics, Inc.

The proposed Jupiter Skimming Orbiter (JSO) will be in a 1.01 RJ by 10 RJ polar orbit, where it will carry instrumentation designed to measure the electromagnetic, electrostatic, and magnetic close-in environment of Jupiter.

C #96 **Mercury Geophysics Mission**

Stan Peale - UC Santa Barbara

Objective is to determine if Mercury has a molten core through gravity field measurements using both an orbiter and lander components of a spacecraft system. Five-year mission to be launched on a Delta II.

C #97 **The Lunar Educator**

Elaine Hansen - Colorado Space Grant Consortium

The Lunar Educator is a small (less than 200 kg) spinning spacecraft placed into a lunar polar orbit with primary goals to increase understanding of lunar polar regions and to educate college students in the realities of spacecraft design and operations. Science payload is an imager plus an ultra stable oscillator for radio science/gravity field determination.

C #98 **Discovery Mission Concept to Investigate Venus' Rotation and Atmospheric Dynamics using Grounded and Floating Radio Beacons**

Charles C. Counselman, III - MIT

The mission is designed to monitor the rotation of the solid portion of the Venus, the circulation of the lower atmosphere, and the atmosphere-surface coupling. The mission involves release of 12 radio beacons around Venus, 6 of which fall to the surface and 6 of which remain aloft. Earth-based differenced long baseline interferometric observation of the beacons are planned for up to 10 years.

C #99 **University Cooperative Venus Mission**

James Arnold - UC, San Diego

This orbiter mission has two major science objectives: (1) study of the minor and trace molecule concentrations in the Venus atmosphere above cloud top and their variation with time, and (2) study of plasma composition and properties, first in the ionosphere and later over a wide range of higher altitudes.

C #100 **Joint Russian/U.S. Phobos Sample Return Mission**

Thomas Duxbury - JPL

The U.S. would supply remote and in situ instruments, the sample return vehicle, and participate in mission planning and operations. The primary goal is to collect and retrieve samples from Phobos and then perform detailed studies of these samples on Earth to increase understanding of Phobos composition, history, and evolution.

N. PI and CO-I Listings Numerical by Concept (Final Version)

San Juan Institute Doug Nash

10/6/92

C#	PI	Co-I, etc.	Institute	Mission
1	Friedrich Hörz		JSC	The Cosmic Dust Collection Facility
		S. Auer	Applied Res. Corp.	
		D.E. Brownlee	U. Washington	
		G. Carle	NASA/ARC	
		S.F. Dermott	U. Florida	
		E. Grun	Max Planck Inst.	
		R.M. Walker	Washington Univ.	
2	Glenn Orton		JPL	Jupiter Polar Orbiter
		K. Baines	JPL	
		Clifford Anger	Itres Res. Ltd.	
		John Caldwell	ISTS	
		Simon Calcutt	Oxford Univ.	
		S. Kim	U. Maryland	
		James Friedson	JPL	
		David McComas	LANL	
		C. Russell	UCLA	
		J. Schofield	JPL	
		Robert A. West	JPL	
		R.A. Wallace	JPL	
		M.Evans	JPL	
		S.S. Weinstein	JPL	
3	Verner E. Suomi		U. Wisconsin Sci. & Eng. Ctr.	Martian Climate Variability A Microsat Approach
		John A. Anderson	U. Wisconsin	
		Sanjay Limaye		
		Thomas Svitek		
		Robert Lindberg		

C#	PI	Co-I, etc.	Institute	Mission
4	Richard Goody		JPL	Venus MultiProbe Mission (VMPM)
		P. Gierasch	Cornell U.	
		R. Greeley	ASU	
		A. Ingersoll	Caltech	
		A. Hou	GSFC	
		D. McCleese	JPL	
		C. Leovy	U. Washington	
		David Crisp	JPL	
		D. Rider	JPL	
		R. Young	ARC	
		R. Zurek	JPL	
		Chad Edwards	JPL	
		Anthony del Genio	GISS	
		Charles Elachi	JPL	
		Uldis Lapins	Hughes Aircraft	
		Ronald Prinn	MIT	
5	Marcia Neugebauer		JPL	A Comet Impact Mission
		M.J.S. Belton	Kitt Peak Nat. Obser.	
		T.J. Ahrens	Caltech	
		Jochen Kissel	Max Planck Inst.	
		Hasso B. Nieman	GSFC	
		Alan D. Stewart	Boeing	
6	Michael J.S. Belton		Natl. Opt. Astron. Obser.	SMACS: Small Missions to Asteroids and Comets
		J. Veverka	Cornell Univ.	
		M. Malin	Malin Space Systems	
		K. Klaasen	JPL	
		Alan Delamare	Ball Aerospace	
		Michael A'Hearn	U. Maryland	
7	Thomas J. Wdowiak		U. Alabama	Ultraviolet Imaging Spectroscopy of Meteors
		Joseph A. Nuth	NASA/GSFC	
		Donald E. Brownlee	U. of Washington	
		John Allen	GSFC	

C#	PI	Co-I, etc.	Institute	Mission
9	Don Burnett		CalTech	Solar Wind Sample Return
		Roger Wiens	Caltech	
		Ian Hutcheon	Caltech	
		Marcia Neugebauer	JPL	
		C.M. Hohenberg	Washington Univ.	
		R.O. Pepin	U. of Minnesota	
		M. Pellin	Argonne National Lab.	
		D.J. McComas	LANL	
		M. Ebihara	Tokyo Metro. Univ.	
		J.T. Gosling	LANL	
11	Robert M. Housley		Rockwell Internat. Sci. Ctr.	Asteroid Sample Return Mission
		Thomas Tombrello	Caltech	
		Chad Goodman	Rockwell ISSD	
12	Samuel Gulkis		JPL	Venus Orbiter-Deep Atmosphere Temperature Sounder
		Michael Janssen	JPL	
		Duane Muhleman	Caltech	
		Richard Wallace	JPL	
		R. Terry Gamber	MM	
		William J. Wilson	JPL	
13	Paul D. Feldman		Johns Hopkins University	Earth-Orbital UV Jovian Observer
		Fran Bagenal	U. of Colorado	
		Michael J.S. Belton	Kitt Peak Nat. Obs.	
		A. Lyle Broadfoot	U. of Arizona	
		John T. Clarke	U. of Michigan	
		Alan Delamere	Ball Aerospace Corp.	
		Arthur L. Lane	JPL	
		David Skillman	GSFC	
14	Benton Clark		Martin Marietta	Comet Coma Rendezvous Sample Return (CCR-SR)
		Don Brownlee	U. of Washington	
		Sherwood Chang	NASA/ARC	
		Merle Alexander	Baylor Univ.	
		Gerhard Schwehm	ESTEC	

C#	PI	Co-I, etc.	Institute	Mission
15	Paul Spudis		Lunar & Planetary Inst.	Mercury Polar Flyby
		Candice Hansen	JPL	
		David Paige	UCLA	
		Albert Metzger	JPL	
		Philip Christensen	ASU	
		Duane Muhleman	Caltech	
		A. Ingersoll	Caltech	
		Hugh Kieffer	USGS	
		John Guest	U. London	
		Paul Lucey	U. Hawaii	
		Jeff Plescia	JPL	
		Martin Slade	JPL	
		Brian Butler	Caltech	
		Steve Wood	UCLA	
		Ashwin Vasavada	UCLA	
16	F.W. Taylor		U. Oxford, Dept. of Physics	Venus Atmospheric Dynamics Imaging Radiometer (VADIR)
		S.B. Calcutt	Oxford University	
17	Larry W. Esposito		U. Colorado, LASP	Venus Composition Probe
		James Pollack	ARC	
		Byron Swenson	SAIC	
		David Grinspoon	LASP	
		Robert Pepin	Minnesota	
		Alvin Seiff	San Jose St. U. Foundation	
		Larry Sromovsky	U. Wisconsin	
		Hasso Niemann	NASA/GSFC	
18	Joseph Veverka		Cornell University	Comet Nucleus Tour - CONTOUR
		M. Belton	KPNO	
		A. Cheng	JHU	
		B. Clark	Martin Marietta	
		R. Farquhar	JHU	
		M. Malin	MSSS	
		P. Thomas	RAND	
		D. Yeomans	JPL	
		H. Niemann	NASA/GSFC	
		J. Kissel	Max Planck Inst.	
20	David F. Blake		NASA/ARC	CHEMIN: Chemistry and Mineralogy using combined X-ray Fluorescence and X-ray Diffraction
		David Vaniman	LANL	
		Friedemann Freund	NASA/ARC	
		David L. Bish	Los Alamos National Lab.	

C#	PI	Co-I, etc.	Institute	Mission
22	J. Derral Mulholland		POD Associates, Inc.	Spatio-Temporal Monitoring of Space Debris
		Dale Atkinson	POD Associates	
		Cassandra Coombs	POD Associates	
		J.J. Wortmann	North Carolina State Univ.	
		Jack McKisson	Inst. for Space Science & Tech.	
		John Oliver	U. of Florida	
		Timothy J. Stevenson	POD Assoc.	
		S. Fred Singer	ISST	
		Jerry L. Weinberg	ISST	
		William H. Kinard	NASA/Langley RC	
23	Glen C. Carle		NASA/ARC	Cometary Coma Chemical Composition -C4- Mission
		Walter Huebner	SWRI	
		Sherwood Chang	NASA/ARC	
		Benton C. Clark	Martin Marietta	
		Merle Alexander	Baylor Univ.	
		Hasso B. Niemann	GSFC	
		Joseph Veverka	Cornell Univ.	
		Don Yeomans	JPL	
		Raymond Goldstein	JPL	
24	Wm. Hayden Smith		Washington University	A Space Experiment
		Ernst Zinner	Washington Univ.	
26	John C. Brandt		Univ. Colorado	The Small Comet and Interplanetary Hydrogen (SCIH) Discovery Mission and Ultraviolet Solar System Observer (UVSSO)
		Michael A'Hearn	U. Maryland	
		J. Ajello	JPL	
		H. Fahr	Inst. fur Astrophysik	
		J.C. Gerard	Inst. d'Astrophysique	
		R. Davis	Colorado Univ./LASP	
		G. Lawrence	CU/LASP	
		C.E. Randall	CU/LASP	
		S. Shore	Computer Sci. Corp.	
		S.C. Solomon	CU/LASP	
		A.I.F. Stewart	CU/LASP	
		P. Weissman	JPL	
		T. Woods	NCAR	

C#	PI	Co-I, etc.	Institute	Mission
28	Faith Vilas		JSC	Inner Planet Spectrographic Imaging Telescope (IPSIT)
		D. M. Hunten	U. Arizona	
		B.R. Sandel	U. Arizona	
		R.B. Singer	U. Arizona	
		A. L. Sprague	U. Arizona	
		M. Tomasko	U. Arizona	
		H.J. Reltsema	Ball Aerospace	
		B. Hapke	U. Pittsburgh	
		D. Domingue	Lunar & Planetary Inst.	
		A. Lyle Broadfoot	U. of Arizona	
		Paul Graf	Ball Aerospace	
29	James L. Burch		Southwest Res. Institute	Comet Activity Probe (CAP)
		Raymond Goldstein	JPL	
		Bruce T. Tsurutani	JPL	
		Thomas E. Moore	NASA/MSFC	
		Jack D. Scudder	NASA/GSFC	
		Hasso B. Niemann	NASA/GSFC	
		Michelle F. Thomsen	Los Alamos Nat. Lab.	
		Tamas I. Gombosi	U. Michigan	
		W. Merle Alexander	Baylor Univ.	
		Thomas E. Cravens	U. of Kansas	
		D. Asoka Mendis	U.C. San Diego	
		Donald K. Yeomans	JPL	
		R. E. Gold	APL/JHU	
		W.F. Huebner	SWRI	
		J.A. Burns	Cornell	

C#	PI	Co-I, etc.	Institute	Mission
32	Daniel Britt		U. Arizona	Rendezvous with Earth Approaching Asteroids (REAAct)
		Mark Sykes	U. Arizona	
		Jeff Bell	UH	
		Klaus Keil	UH	
		Dave Tholen	UH	
		Karen Meech	UH	
		Clark Chapman	PSI	
		Don Davis	PSI	
		R. Kolvoord	LPL	
		Steve Ostro	JPL	
		L. Lebofsky	LPL	
		L. McFadden	U. Maryland	
		D. Rabinowitz	LPL	
		Charles F. Lille	TRW	
		Don Yeomans	JPL	
		Mike Drake	LPL	
		Tom Gehrels	LPL	
		Steve Larson	LPL	
		David Kring	LPL	
		J. Scotti	LPL	
		Albert Sun	McDonnel Douglas	
		Tom Economu	Chicago	
		David Morrison	NASA/ARC	
34	Robert M. Nelson		JPL	Hermes Global Orbiter: A Mission to Mercury
		Linda J. Horn	JPL	
		San-San Kuo	Comp. Sci. Corp.	
		Ken Manatt	Comp. Sci. Corp.	
		Jack Freidenthal	TRW	
		Ken Rourke	TRW	
		William D. Smythe	JPL	
		Brad Wallis	JPL	
		Bruce W. Hapke	U. of Pittsburgh	
		James Garvin	GSFC	
		John Guest	Univ. College London	
		William McClintock	U. Colorado	
		Karen E. Sommons	U. Colorado	
		Arthur L. Lane	JPL	
		Rosaly M. Lopes	JPL	
		Ray B. Morris	JPL	
		Adrianna Ocampo	JPL	
		Chris Russell	UCLA	
		James R. Weiss	JPL	
		Chen Wan Yen	JPL	

C#	PI	Co-I, etc.	Institute	Mission
35	Hunter Waite		Southwest Res. Inst.	A Planetary/Heliospheric Reconnaisance of Dynamics: Ionosphere, Thermosphere, and Exosphere (APHRODITE)
		Thomas E. Cravens	U. of Kansas	
		Andrew Nagy	U. of Michigan	
		S. Bougher	U. Arizona	
		Karoly Szego	Central Research Inst.	
		Janet Luhmann	UCLA	
		R. Elphic	LANL	
		Oleg Vaisberg	Russian Inst. for Space Res.	
		T. Killeen	U. Michigan	
		T. Gamber	Martin Marietta	
		R. Wallace	JPL	
37	C.T. Russell		UCLA	Venus CLOUD Mission
		K.H. Baines	JPL	
		W.J. Borucki	NASA/ARC	
		R.W. Carlson	JPL	
		R.C. Elphic	LANL	
		D.A. Gurnett	U. Iowa	
		W.S. Kurth	U. Iowa	
		J.G. Luhmann	UCLA	
		D.J. McComas	LANL	
		W. Riedler	Space Res. Inst. Graz Austria	
		K. Shcwingenschuh	Space Res. Inst. Graz Austria	
		W.D. Smythe	JPL	
		R.J. Strangeway	UCLA	
		R.C. Snare	UCLA	
38	Kevin H. Baines		JPL	Venus 4-D Discovery Mission
		R. Carlson	JPL	
		D. Crisp	JPL	
		A. Delamere	Ball Aerospace Syst. Grp.	
		S. Limaye	Univ. Wisconsin	
		C. Russell	UCLA	
		W.H. Smith	Washington Univ.	
		J.T. Schofield	JPL	
		D.R. McMann	Ball	
		R.A. Wallace	JPL	
		M.D. Garcia	JPL	
39	Mark Hickman		NASA Lewis Res. Ctr.	Magetospheric Mapping and Current Collection in the Region from LEO to GEO
		Barry Hillard	Lewis RC	
		Dale Ferguson	Lewis RC	

C#	PI	Co-I, etc.	Institute	Mission
40	Paul Weissman		JPL	SOCCER Pathfinder
		Marcia Neugebauer	JPL	
		Don Yeomans	JPL	
		Peter Tsou	JPL	
		Joseph Veverka	Cornell Univ.	
		Don Brownlee	Univ. Washington	
		Tony McDonnell	U. Kent Canterbury	
		Hasso B. Nieman	GSFC	
		Kuninori Vesugi	ISAS Tokyo	
		Richard Reinert	Ball Aerospace	
		Philip Knocke	JPL	
42	Michael C. Malin		Malin Space Science Systems	Venus Geophysical Network Pathfinder
		Duncan C. Agnew	UCSD	
		Robert Grimm	ASU	
		Steven Constable	UCSD	
		T. Guy Masters	UCSD	
43	Jeff Plescia		JPL	Lunar Interior Explorer Mission
		Hitoshi Mizutani	ISAS Tokyo	
44	Jeff Plescia		JPL	Lunar Geophysical Explorer Mission
		Rick Elphic	LANL	
		Jim Garvin	NASA/GSFC	
		Lon Hood	Univ. Arizona	
		Duane Muhleman	Caltech	
		William Sjogren	JPL	
		Don Hunten	U. Arizona	
		Bill McClintock	U. Colorado	
		Tom Morgan	NASA HQ	
		Alan Stern	SwRI	
46	Arden Albee		Caltech	Flyby Sample Return via Sample of Comet Coma Earth Return - SOCCER
		Peter Tsou	JPL	
		Don Brownlee	U. of Washington	
		Don S. Burnett	Caltech	
		Marcia Neugebauer	JPL	
		Zdenek Sekanina	JPL	
		Robert Farquhar	JHU/APL	
		Hitoshi Mizutani	ISAS Tokyo	
		Mikio Shumigu	ISAS Tokyo	
		Kuninori Uesugi	ISAS Tokyo	

C#	PI	Co-I, etc.	Institute	Mission
47	Joseph Veverka		Cornell University	Mainbelt Asteroid Exploration/ Rendezvous (MASTER)
		R. Binzel	MIT	
		R.H. Brown	JPL	
		M. Gaffey	RPI	
		S. Squyres	Cornell	
		P. Thomas	RAND	
		J. Trombka	NASA/GSFC	
		D. Yeomans	JPL	
		K. Klaasen	JPL	
		E. Evans	GSFC	
		T. Gamber	Martin Marietta	
		S. Miller	JPL	
49	Sanjay S. Limaye		U. Wisconsin-Madison	Mars Operational Environmental Satellite (MOES)
		Ralph Kahn	JPL	
		Richard W. Zurek	JPL	
		Dan McCleese	JPL	
		H.E. Revercomb	SSEC	
		L.A. Sromovsky	SSEC	
		D. Muhleman	Caltech	
		A. Ingersoll	Caltech	
		M. Allison	GSFC	
		D. Paige	UCLA	
		T. Clancy	U. Colorado	
		S. Silverman	SBRC	
		S. Ackerman	U. Wisconsin-Madison	
		C. Hayden	U. Wisconsin-Madison	
51	John Langford		Aurora Flight Sciences	Mars Atmospheric Aircraft Platforms
52	Duane O. Muhleman		Caltech	MIRROR: Mercury Imaging & Radar Ranging Orbital Reconniassance
		G. Edward Danielson	Caltech	

C#	PI	Co-I, etc.	Institute	Mission
53	Albert Metzger		JPL	Mercury Mapping Orbiter Mission
		James Arnold	UCSD	
		Clark Chapman	Planetary Sci. Inst.	
		Robert Lin	UCB	
		David Paige	UCLA	
		Christopher Russell	UCLA	
		William Sjogren	JPL	
		Robert Strom	U. Arizona	
		Merton Davies	RAND	
		Lyn D. Pleasance	LLNL	
		Jacob I. Trombka	GSFC	
		Robert C. Reedy	LANL	
		Chen-wan L. Yen	JPL	
		Kendra L. Short	JPL	
54	Bruce Murray		Caltech	Pluto/Charon Flyby Mission
		G. Edward Danielson	Caltech	
		Robert Lindberg		
55	James W. Head		Brown University	Discovery Venera Surface-Atmosphere Geochemistry Experiments (SAGE)
		Ellen Stofan	JPL	
		Ray Arvidson	Washington Univ.	
		Dave Crisp	JPL	
		Thomas Donahue	U. of Michigan	
		Bruce Fegley	Washington Univ.	
		Ron Greeley	ASU	
		John Mustard	Brown Univ.	
		Kerry Nock	JPL	
		Steve Saunders	JPL	
		Steve Squyres	Cornell Univ.	
		J. Trombka	GSFC	
		Roald Kremnev	Babakin	
		Arnold Selivanov	Glavkosmos	
		Alexander Basilevsky	Vernadsky	
		Vassily Moroz	IKL	

C#	PI	Co-I, etc.	Institute	Mission
58	Peter L. Bender		U. Colorado	Lunar Interior Structure Mission
		Charles D. Edwards	JPL	
		Robert Preston	JPL	
		Irwin Shapiro	Harvard Univ.	
		Roger J. Phillips	Washington Univ.	
		A.E.C. Rogers	Haystack Obs.	
		G. Schubert	UCLA	
		Sean C. Solomon	Carnegie Inst.	
		K. Knock	JPL	
		C.F. Yoder	JPL	
		B. Bertotti	U. Pavia, Italy	
		J.E. Faller	U. Colorado	
		W.M. Folkner	JPL	
		J.G. Williams	JPL	
60	Robert C. Reedy		Los Alamos National Lab.	A Mercury Interior, Surface and Environment Mission Concept
		Daniel N. Baker	NASA/GSFC	
		Darrell M Drake	LANL	
		William C. Feldman	LANL	
		S. Peter Gary	LANL	
		Galen R. Gisler	LANL	
		David J. McComas	LANL	
		P.E. Clark	GSFC	
		L.G. Evans	GSFC	
		J.A. Slavin	GSFC	
		R.Starr	GSFC	
		Chris T. Russell	UCLA	
		Jacob I. Trombka	NASA/GSFC	
		R.C. Elphic	LANL	
		J.E. Nordholt	LANL	
		A.E. Metzger	JPL	
		R.P. Lin	UC Berkeley	
61	William J. Borucki		NASA/AMES	FRESIP: Frequency of Earth-sized Planets
		William D. Cochrane	U. Texas	
		Harold Reitsema	Ball Aerospace	
		David Koch	NASA/ARC	
		Paul Davis	NASA/ARC	
		R. melugin	NASA/ARC	
		R. Hanel	NASA/ARC	

C#	PI	Co-I, etc.	Institute	Mission
64	Lee S. Mason		NASA Lewis Res. Ctr.	Combined Lander and Instrumented Rover (CLIR) A Robotic Lunar Rover Mission Proposal
		Kevin Dowling	Carnegie Mellon Univ.	
65	Bruce G. Bills		NASA/GSFC	Koati: A Lunar Polar Orbiter Mission
		Jim Abshire	NASA/GSFC	
		Herb Frey	NASA/GSFC	
		Jim Garvin	NASA/GSFC	
		Dave Skillman	NASA/GSFC	
		Maria Zuber	NASA/GSFC	
		Ray Arvidson	Washington Univ.	
		Thomas C. Duxbury	JPL	
		Michael C. Malin	Malin Space Sci. Syst.	
		R. Steven Nerem	GSFC	
		Roger J. Phillips	Washington Univ.	
		David Smith	GSFC	
		Sean C. Solomon	Carnegie Inst.	
66	Bruce G. Bills		NASA/GSFC	Mallcu: A Mercury Polar Orbiter Mission
		Jim Abshire	NASA/GSFC	
		Mario H. Acuna	GSFC	
		Herb Frey	NASA/GSFC	
		Jim Garvin	NASA/GSFC	
		Dave Skillman	NASA/GSFC	
		Maria Zuber	NASA/GSFC	
		Ray Arvidson	Washington Univ.	
		Thomas C. Duxbury	JPL	
		Michael C. Malin	Malin Space Sci. Syst.	
		R. Steven Nerem	GSFC	
		Roger J. Phillips	Washington Univ.	
		David Smith	GSFC	
		Sean C. Solomon	Carnegie Inst.	
		John E. Connemey	GSFC	
		James W. Head	Brown Univ.	

C#	PI	Co-I, etc.	Institute	Mission
72	Wm. Hayden Smith		Washington Univ.	Lunar Ultra-Violet Infrared Spectrometer
		L. Haskin	Washington Univ.	
		R. Phillips	Washington Univ.	
		R. Arvidson	Washington Univ.	
		W. McKinnon	Washington Univ.	
		R. Korotev	Washington Univ.	
		S. Larson	Arizona	
		B. Hapke	Pittsburgh	
		P. Lucey	Univ. of Hawaii	
		P. Hammer	NASA/ARC	
73	Wm. Hayden Smith		Washington Univ.	The Comet Nucleus Observer
		Dale Cruikshank	NASA/ARC	
		Fancisco Valero	NASA/ARC	
		M. Combi	U. Michigan	
74	Len Tyler		Stanford University	Radio Science & Astronomy Mission (RSAM) Giant Outer Planet Orbiters
		John Anderson	JPL	
		Sam Gulkis	JPL	
		Don Sweetnam	JPL	
		T. Spilker	JPL	
		Susan Borutzki	JPL	
75	Bradley C. Edwards		Los Alamos National Lab.	The Prospector Mission
		Mel Ulmer	Northwestern University	
		Carle Pieters	Brown Univ.	
		Carl Henrikson	Ball Aerospace	
		David Vaniman	Los Alamos	
		Grant Heiken	Los Alamos	
		Simon Labov	LLNL	
76	William V. Boynton		U. Arizona	Comet Nucleus Penetrator
		Jack Trombka	GSFC	
		Mike Burke	U. Arizona	
		Steve Larson	U. Arizona	
		Jonathan Lunine	U. Arizona	
		Wayne Young	Sandia Nat. Lab.	
		Don Yeomans	JPL	

C#	PI	Co-I, etc.	Institute	Mission
77	Eugene M. Shoemaker		U.S. Geological Survey	Near Earth Asteroid Returned Samples (NEARS)
		Richard P. Binzel	MIT	
		James Burke	JPL	
		Donald S. Burnett	Caltech	
		Andrew F. Cheng	JHU	
		Robert Farquhar	JHU	
		Michael Gaffey	RPI	
		John H. Jones	JSC	
		Lucy-Ann McFadden	U. Maryland	
		Steven J. Ostro	JPL	
		Harry Y. McSween	U. Tennessee	
		Timothy D. Swindle	U. Arizona	
		Isabel Lewis	LLNL	
		Jim McAdams	SAIC	
78	W. M. Alexander		Baylor University	Comet Coma Sample Return (CCSR)
		William G. Tanner	Baylor University	
		Carl R. Maag	Science Applications Inter. Corp.	
		J.A.M. McDonnell	U. Kent, Canterbury	
		Walter Huebner	Southwest Res. Inst.	
		Daniel Boyce	Southwest Res. Inst.	
		James Burch	Southwest Res. Inst.	
		Hitoshi Mizutani	Inst. of Space & Astronautical Sci.	
		R. Farquhar	JHU/APL	
		R.A. McDonald	Baylor Univ.	
		M. Zolensky	JSC	
79	Prof. T. L. Killeen		U. Michigan	A Mars Upper Atmos. Dynamics, Energetics and Evolution Mission (MUADEE)
		L.H. Brace	U. Michigan	
		G.R. Carignan	U. of Michigan	
		R.E. Hartle	NASA/GSFC	
		R. A. Heelis	U. Texas	
		B. Jakosky	U. of Colorado	
		J.G. Luhmann	UCLA	
		H. G. Mayr	NASA/GSFC	
		M.H. Acuna, H. B. Niemann	GSFC	
		J.A. Slavin	NASA/GSFC	
		R. Zurek	JPL/Caltech	
		S.W. Bougher	U. Arizona	
		T.I. Gombosi, A.F. Nagy	U. Michigan	
		L.J. Paxton	APL/JHU	
		J.H. Yee	APL/JHU	
		A.I.F. Stewart	U. Colorado	

C#	PI	Co-I, etc.	Institute	Mission
80	Daniel T. Lyons		JPL	The Little Dipper" Mars Aeronomy, Gravity, and Radio Science
		Bill Sjogren	JPL	
		Gerald Keating	NASA/Lang. RC	
		Brian Haas	NASA/ARC	
		Paul Graf	Ball Aerospace	
		Franklin Hurlbut	UC Berkeley	
		Arv Kliore	JPL	
		Vince Anicich	JPL	
		Mark Allen	JPL	
		Jim Neuman	Martin Marietta	
81	Ellen R. Stofan		JPL	Venus Interior Structure Mission (VISM)
		David Stevenson	Caltech	
		David Crisp	JPL	
		Bruce Banerdt	JPL	
		Paul Lundgren	JPL	
		Kerry Nock	JPL	
		Roger Phillips	Washington Univ.	
		David Tralli	JPL	
		Suzanne Smrekar	JPL	
		Sean C. Solomon	Carnegie Inst.	
83	David A. Paige		UCLA	The Mars Polar Pathfinder
		David Crisp	JPL	
		Hermann Englehardt	Caltech	
		James Gooding	NASA/JSC	
		Robert Haberle	NASA/ARC	
		Barclay Kamb	Caltech	
		Daniel McCleese	JPL	
		Lonnie Thompson	Ohio State Univ.	
		Ellen Mosley-Thompson	Ohio State Univ	
		Richard Zurek	JPL	
		Charles R. Bentley	U. Wisconsin-Madison	
		C. Bernard Farmer	SJI	
		Richard K. Moore	U. Kansas	
		Frank D. Palluconi	JPL	
		Gerald Schubert	UCLA	
		Ronald L. Shreve	UCLA	
		Stephen E. Wood	UCLA	

C#	PI	Co-I, etc.	Institute	Mission
84	D.E. Shemansky		USC Dpt. Aerospace Eng.	A Proposal for Atmospheric Explortion of the Moon
		D. A. Erwin	USC	
		D.L. Judge	USC	
		H.S. Ogawa	USC	
		M.A. Gruntman	USC	
		J.M. Ajello	JPL	
		J.O. Maloy	Mountain Instruments Corp.	
85	William D. Smythe		JPL	Io Mapper
		R. Lopes	JPL	
		A. Ocampo	JPL	
		T.N. Gautier	JPL	
		R. Greeley	ASU	
		L. Soderblom	USGS Flagstaff	
		E. Lellouch	Paris Obs.	
		F. Fanale	U. Hawaii	
		S. Silverman	Santa Barbara Res. Ctr.	
		E. Russell	Santa Barbara Res. Ctr.	
		R. Nelson	JPL	
86	Wallace Fowler		Univ. Texas	Mars Gravity Measurement/ Surface Penetrator Assembly Mission
		Michael Howard	Tracor Aerospace	
		John B. Lundberg	UT Austin	
87	William Red Whittaker		Carnegie Mellon Univ.	Lunar Lava Tube Explorer
		Eric Krotkov	Carnegie Mellon Univ.	
		Kevin Dowling	Carnegie Mellon Univ.	
		Gerald Roston	Carnegie Mellon Univ.	
88	John B. Kumer		Lockheed Palo Alto Res. Lab.	Solar System Exploration Cryogenic Telescope (SSECT)
		Aidan Roche	Lockheed Palo Alto	
		M.F. A'Hearn	U. Maryland	
		S.D. Price	Phillips Lab., Hanscom AFB	
		R.H. Brown	JPL	
		E.T. Young	U. Arizona	

C#	PI	Co-I, etc.	Institute	Mission
90	Alan Stern		Southwest Research Inst.	Chiron Discovery Flyby
		M. A'Hearn	U. Maryland	
		Benton Clark	Martin Marietta	
		Michael Festou	CNRS	
		M. Sykes	U. Arizona	
		Walter Huebner	SwRI	
		P. Weissman	JPL	
		Jochim Kissel	Max Planck Inst.	
		Jonathan Lunine	U. Arizona	
		Hasso B. Niemann	GSFC	
		Joseph Veverka	Cornell	
92	Jacque Blamont		Univ. Paris & JPL	Exploration of Mars in the 90's
93	Michael Mendillo		Boston University	Satellite for Imaging Planetary Alkaline Comas (SIPAC)
		Jeffrey Baumgardner	Boston Univ.	
94	David R. Scott		Scott Science & Tech., Inc.	ULYSSES: A Return to the Hadley Apennine, New Steps in Solar System Exploration
		Rodney Brooks	MIT	
		Paul D. Spudis	Lunar & Planetary Inst.	
		Graham Ryder	Lunar & Planetary Inst.	
		Colin Francis	Space Syst. Loral	
		Robert D'Ausilio	Intraspace, Inc.	
95	James W. Warwick		Radiophysics Inc. Co.	Polar Orbiters for Giant Planet Exploration
		J.H. Romig	Radiophysics, Inc.	
		D.R. Evans	Radiophysics, Inc.	
		J.E.P. connerney	GSFC	
		W. Hubbard	U. Arizona	
		G.L. Tyler	Stanford	
96	Stan Peale		UC Santa Barbara	Mercury Geophysics Mission
		Peter Bender	U. of Colorado	
		Gerald Schubert	UCLA	
		Sean Soloman	Carnegie Inst.	
		Dan Wenkart	JPL	
		Ron Hellings	JPL	
		Charles Edwards	JPL	
		Mark Vincent	JPL	
		Xiaping Wu	U. Colorado	

C#	PI	Co-I, etc.	Institute	Mission
97	Elaine Hansen		U. Colorado	The Lunar Educator
		Brent Helleckson	U. colorado	
		Michel Loucks	U. colorado	
		Peter Warren	U. Colorado	
		Bruce Schulz	U. Colorado	
		Allison Kipple	U. Colorado	
		Chauncey Uphoff	Ball Aerospace	
		Al Schallenmuller	Martin Marietta	
		Alan Delamare	Ball Aerospace	
		Jim French	Consultant	
98	Charles C. Counselman III		MIT	Venus' Rotation and Atmospheric Dynamics using Grounded and Floating Radio Beacons
		Gordon H. Pettengill	MIT	
		Joseph H. Binsack	MIT	
99	James Arnold		UC San Diego	University Cooperative Venus Mission
		Sally Ride	UCSD	
		Michael Wiskerchen	UCSD	
		Elaine Hansen	U. Colorado	
		Alan Schneider	UCSD	
		Mark Thiemens	UCSD	
		Martin Wahlen	UCSD	
		Gary Emerson	U. Colorado	
		Albert Metzger	JPL	
		Christopher Russell	UCLA	
		Paul Coleman	UCLA	
		Donald Cobb	LANL	
		David McComas	LANL	
		William Feldman	LANL	
100	Tom Duxbury		JPL	Joint Russian/U.S. Phobos Sample Return Mission
		Dale Cruikshank	NASA/ARC	
		J. Gooding	NASA/JSC	
		D. Matson, C. Elachi	JPL	
		L. Soderblom	USGS	
		J. Veverka	Cornell	
		G. Wasserberg, A. Albee	Caltech	
		J.P. Bibring	IAS, France	
		W. Ballhaus, B. Clark	Martin Marietta	
		J. Blamont	CNES, France	
		A. Zakharov	Space Research Inst.	
		G. Neukum	DLR, Germany	